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DEPARTMENT OF THE ARMY FIELD MANUAL

OPERATIONAL ASPECTS OF RADIOLOGICAL DEFENSE



**HEADQUARTERS, DEPARTMENT OF THE ARMY
JANUARY 1963**

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FIELD MANUAL

No. 3-12

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C., 31 January 1963

OPERATIONAL ASPECTS OF RADIOLOGICAL DEFENSE

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Purpose

This manual furnishes guidance in the organization and operations of appropriate elements of the field army in the collection and use of radiological contamination intelligence.

2. Scope

The material presented in this manual is applicable to nuclear warfare for the field army and with modification for CONUS armies and similar commands. It establishes the techniques and procedures for radiological monitoring, radiological survey, processing radiological contamination information, residual radiation calculations, and the operations of the Chemical, Biological, and Radiological Element (CBRE).

3. Definitions and Terms and Symbols

a. Definitions. Terms defined in other publications are not redefined in this manual except those which are particularly applicable to the subject matter.

- (1) *Area survey meter.* As used in this manual, the term "area survey meter" will refer to those radiacmeters used to measure dose rates during the monitoring and surveying of large-area radiological contamination.
- (2) *Large-area radiological contamination.* As used in this manual, the term "large-area radiological contamination" will refer to the contamination of large ground areas with radioactive gamma-emitting materials. The means by which these large areas are contaminated may be any one or a combination of the means described in (3), (4), and (5) below.

(3) *Militarily significant fallout.* Radioactive contamination capable of inflicting casualty-producing doses to personnel and which will arrive on the ground within a few hundred kilometers of ground zero within one day after the burst. A nuclear burst produces militarily significant fallout whenever the fireball touches the surface of the earth. When this occurs, surface material is vaporized and carried up into the radioactive cloud. As the cloud cools, radioactive products become intermingled with the vaporized surface material and condense into dustlike particles. These particles are known as fallout particles and the radiation hazard they create as they fall and concentrate on the earth's surface is called "fallout." The fallout area varies in size with the fission yield and total yield and the degree of fireball contact with the earth. The shape of the area varies with the weather conditions existing at the time of and within a few hours after the nuclear burst. Small yield weapons may produce a variation of fallout called "rainout." This phenomenon occurs when a portion of the radioactive cloud stabilizes below or passes through rain and snow clouds. In this event, precipitation from these clouds will be contaminated.

(4) *Induced radiation.* Radioactive contamination near ground zero resulting from capture of neutrons by various elements in the soil, especially sodium and manganese. In a nuclear burst where the fireball does not touch the surface of the ground, induced radia-

tion may be significant but fallout will generally be unimportant. With a surface or subsurface burst, there will undoubtedly be a considerable amount of induced radioactivity but radioactivity from fallout will be so much greater that induced radiation can be considered negligible in comparison.

- (5) *Radiological agent.* Any of a family of substances that is capable of producing casualties by emitting radiation. Radiological agents may be selected radioactive isotopes prepared in a nuclear reactor, or radioactive waste obtained from a nuclear reactor, or radioactive isotopes produced from a nuclear explosion. As used in this manual, radiological agents refer to contamination other than fallout or induced radiation.
- (6) *Operation exposure guide (OEG).* The maximum amount of nuclear radiation which the commander considers his unit may be permitted to receive while performing a particular mission or missions.
- (7) *Effective dose.* That portion of a total dose received in any period of time which is numerically equivalent to an acute dose (within 24 hours) which will produce the same biological effects.
- (8) *Reference dose.* The amount of penetrating, whole body radiation which causes certain biological effects in personnel.
- (9) *Rad.* Unit of absorbed dose of ionizing radiation. It represents absorption of 100 ergs of nuclear (or ionizing) radiation per gram of absorbing material.
- (10) *Hot line.* A line which defines maximum dose-rate points extending from ground zero down the center of a radiological contamination pattern.
- (11) *Militarily significant contamination.* Radio active contamination capable of inflicting casualty-producing doses to personnel.

b. Terms and Symbols.

Symbol	Term
AGCF	Air-ground correlation factor
AR	Aerial dose rate
CF	Correction factor (used in calculations of dose which are time dependent).
CF	Correlation factor (used in calculations involving shielding).
D	Total dose
D _a	Calculated dose
D _t	True dose
FRRS	Full remaining radiation service
FSE	Fire Support Element
GCT/ZULU	Greenwich Civil Time
GR	Ground dose rate
GZ	Ground zero
ID	Inside dose rate; inside dose
LRRS	Limited remaining radiation service
ln	Natural logarithm
n	Decay constant
NBC	Nuclear, Biological, Chemical
NF	Normalizing factor
NRRS	No remaining radiation service
OCF	Overall correction factor
OD	Outside dose rate; outside dose
OEG	Operation exposure guide
R ₁	Dose rate at, or referenced to, one hour after burst (H + 1).
R _{avg}	Average dose rate
R _{max}	Maximum dose rate
R _t	Dose rate at a time after burst, other than H + 1.
STANAG	Standardization Agreement
T	Time
T _e	Time of entry into a contaminated area.
T _p	Projection of time
T _s	Time of stay (stay time) in a contaminated area.
T _x	Time of exit from a contaminated area.
TF	Transmission factor

4. Changes and Revisions

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commanding Officer, U.S. Army CBR Combat Developments Agency, Fort McClellan, Ala.

Section II. RADIOLOGICAL INTELLIGENCE

5. Types of Radiological Intelligence

To aid the commander and his staff in evaluating the effects of radiological contamination on the mission of the unit, the following forms of intelligence, listed in order of preparation, will be disseminated:

a. Fallout Prediction. A fallout prediction indicates a general area outside of which a specific degree of hazard will probably not occur. The reliability of a fallout prediction is primarily related to the reliability of the upper air wind data and the nuclear burst data upon which it is based; and secondarily, to the fallout prediction method used in preparation, detailed or simplified. The bases for the preparation of fallout predictions are listed below in approximate order of reliability. For detailed discussion and illustration of fallout prediction, see TM 3-210.

- (1) Target analyses for friendly nuclear bursts from which fallout is expected or intended must include a fallout prediction. These fallout predictions should be the most reliable since all nuclear burst data will normally be known. The limited availability of current upper air wind data over enemy targets deep in enemy territory may reduce the reliability of fallout predictions. For detailed discussion, see FM 101-31.
- (2) Target analyses for friendly nuclear bursts where fallout is not intended may require a fallout prediction if the delivery system height-of-burst errors are large or if a deliberate fallout risk is taken in order to insure achievement of the desired target effect.
- (3) Any nuclear burst, when postburst information indicates that fallout will probably occur or when fallout starts, will require that a fallout prediction be prepared unless already available ((2) above).
- (4) Studies of the vulnerability of friendly troop dispositions to nuclear attack must include fallout predictions. The fallout predictions for these vulner-

ability studies are usually prepared by the simplified method.

b. Radiological Contamination Overlay. Radiological contamination overlays indicate the contamination in areas of interest. The overlay is based on measured dose-rate and outlines the known areas of contamination. The overlay provides sufficient data about dose rates existing within the contaminated area to permit determination of the effects of the hazard on operations conducted in the area. Radiological contamination overlays may vary from the hasty type to the detailed type. When time or operational requirements limit the information flow, in fluid or vague situations, or in areas not controlled by friendly troops, hasty contamination overlays or fallout predictions may be the only types of radiological contamination intelligence available to the commander. When time and operational limitations are less severe, the detailed contamination overlay can be prepared. Brief descriptions and illustrations of the two extremes of contamination overlays follow:

- (1) *Hasty radiological contamination overlay* (fig. 1). The hasty contamination overlay shows the general limits of the militarily significant contamination (par. 117c(1)) and the minimum dose-rate information necessary to satisfy command requirements.
- (2) *Detailed radiological contamination overlay* (fig. 2). The detailed contamination overlay defines the limits of the militarily significant contamination more precisely than does the hasty overlay and shows dose-rate contours. It may include such refinements as dose calculations for critical crossing routes or points and time-of-completion lines.

6. Forms of Radiological Contamination Information

The following radiological contamination information must be available to develop the intelligence described in paragraph 5.

a. Basic Prediction Data. The basic data required for fallout predictions consist of upper

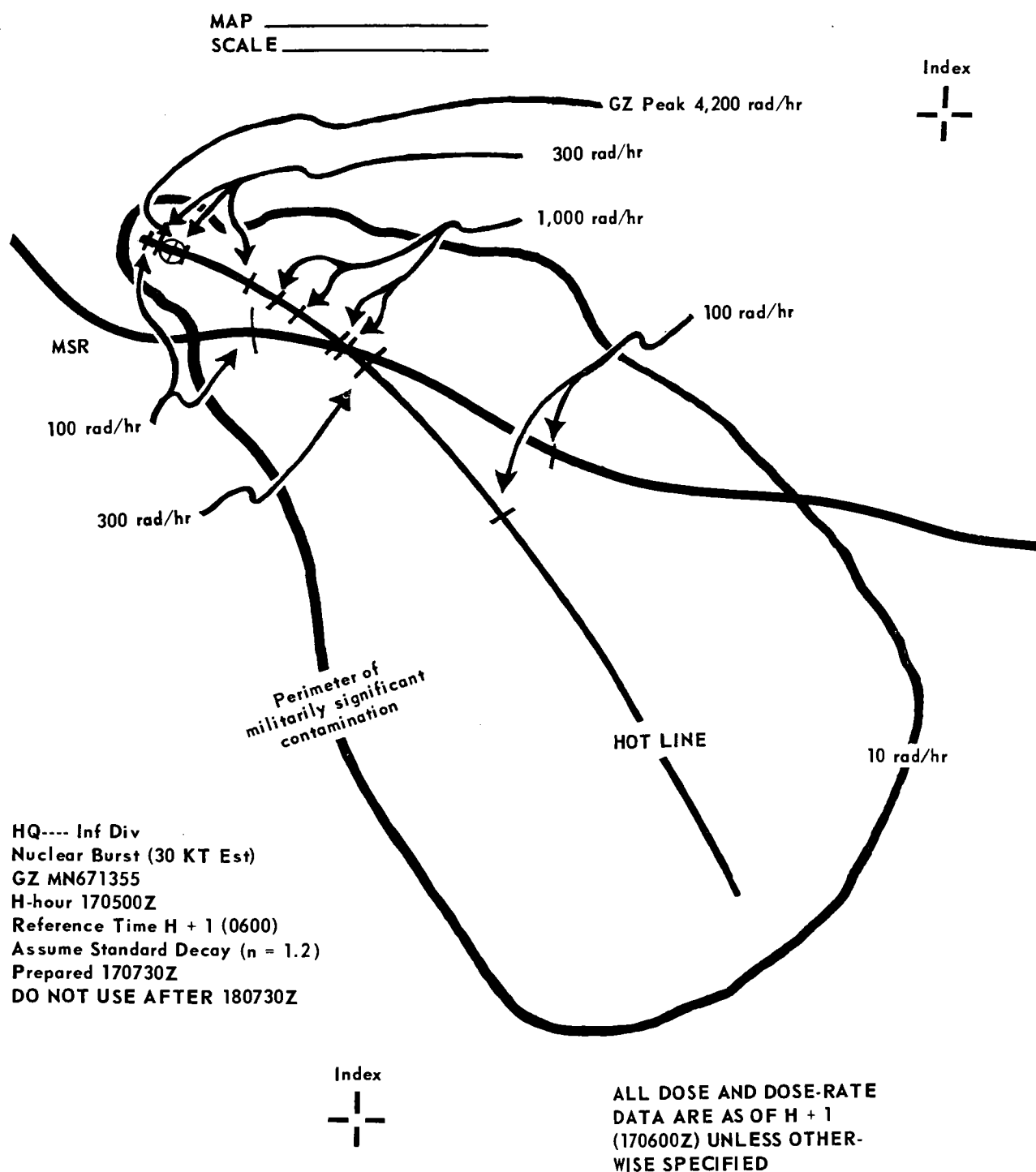
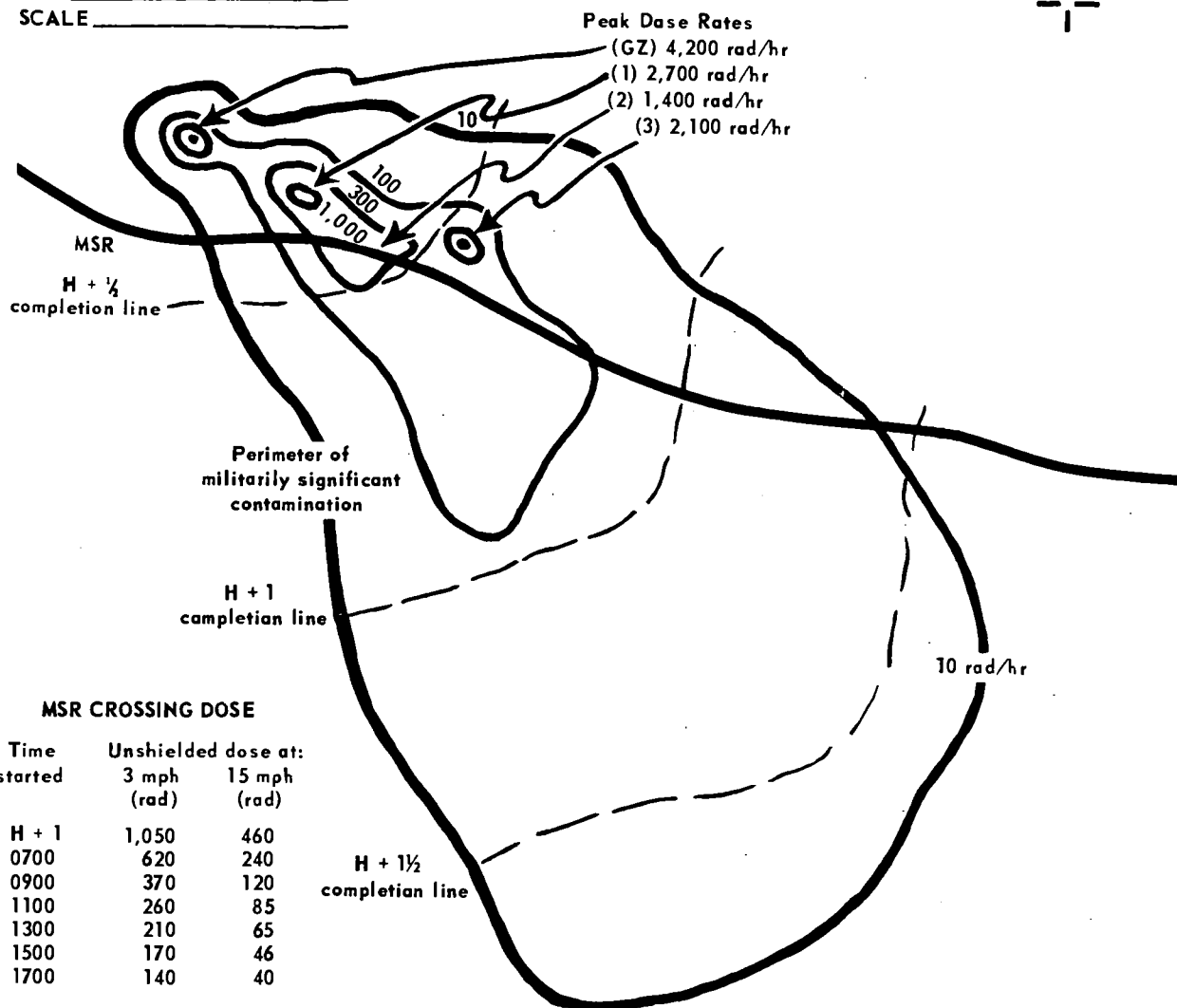


Figure 1. Hasty radiological contamination overlay.

MAP _____
SCALE _____

Index
+



HQ ---- Inf Div
Nuclear Burst (30 KT)
GZ MN671355
H-hour 170500Z
Reference Time $H + 1$ (0600)
Standard Decay ($n = 1.2$)
Prepared 171000Z
DO NOT USE AFTER 191000Z

Index
+

All fallout completed by
 $H + 2$ hours (0700)

ALL DOSE AND DOSE-RATE DATA
ARE AS OF $H + 1$ (170600Z)
UNLESS OTHERWISE SPECIFIED

Figure 2. Detailed radiological contamination overlay.

air wind data and nuclear burst data. Procedures for the collection of nuclear burst data are described in chapter 2. Procedures for the utilization of upper air wind data are covered in TM 3-210.

b. Radiological Monitoring Data. Radiological monitoring data provide part of the information necessary for the contamination overlays. Procedures for developing these data are described in chapter 3.

c. Hasty Radiological Survey Data. Hasty radiological survey data provide, in the least possible time and in areas where monitoring information is incomplete, the minimum essential information necessary for command action. Details of the procedures for developing hasty survey data are described in chapter 4.

d. Detailed Radiological Survey Data. Detailed radiological survey data complete the data necessary for preparation of the contamination situation overlay. Details of the procedures used to develop these data are described in chapter 4.

7. Command and Staff Responsibilities for the Collection Effort

Except for the general staff facilities indicated in *c* below, the radiological information collection effort is accomplished by using organic personnel and equipment on an additional duty basis. Command and staff actions by organizations, as indicated below, are necessary to insure an adequate collection effort.

a. Company/Battery Units. Radiological monitors and radiological survey parties from company/battery CBR teams provide the basic requirements of the collection effort. Details of designating, equipping, and employing these individuals are specified by the unit commander, SOP's or other standing instructions. In order to insure an adequate collection effort, the company/battery commander provides the following minimum requirements from established unit CBR teams:

- (1) Two trained monitors are maintained for each area survey meter authorized and are employed to collect monitoring information. They may also be used to fulfill requirement ((2) below).

- (2) One trained and equipped ground survey party (par. 50) is organized within the unit CBR teams and maintained for each area survey meter authorized to satisfy requirements of the collection effort. The monitor from each survey party is trained to perform both ground survey duties and aerial survey duties. Monitors for aerial survey parties are not normally drawn from aviation units.

- (3) Selected individuals are trained to satisfy the requirements for nuclear burst estimation, nuclear burst reporting, and unit fallout prediction (ch. 2 and TM 3-210). The CBR team chief in special situations may be called on to act as a control party.

b. Brigade, Battalion, and Similar Organizations. Information from the collection effort flows from the collecting agency (*a* above) to the evaluating facilities of *c* below. Monitoring and nuclear burst reports flow through the headquarters of battalion, brigade, and similar organizations where the data are screened for both content and priority. These organizations forward the minimum data required to illustrate the typical contamination status in areas of responsibility or the minimum data necessary to determine yield, time, and ground zero of an observed nuclear burst. To satisfy responsibilities for survey, each of these headquarters establishes and trains at least one radiological control party (par. 50). Staff functions for brigade, battalion, and similar organizations parallel division staff functions.

c. Division, Corps, and Field Army. Staff responsibilities for developing the intelligence and information described in paragraphs 5 and 6 above are delineated in FM 101-5. In major commands within a field army, a chemical, biological, and radiological element operates in the tactical operations center (TOC). As a part of its mission this element performs, under supervision of the chemical officer, radiological functions which assist the G2 in the radiological intelligence effort. TC 101-2, TOE 3-500E, and chapter 8 establishes the mission, responsibilities, and operational procedures of the CBRE in the radiological intelligence effort.

d. CONUS Army, Logistical, and Similar

Commands. CONUS Army, logistical, and other major commands having area responsibilities, organize parallel to equivalent tactical commands in order to satisfy their radiological intelligence requirements. Personnel and equipment required for these purposes are drawn from within established TOE, TD, or TA authorizations.

e. Chemical, Biological, and Radiological

Element. At division and higher or equivalent headquarters, the agency (CBRE) performing the radiological functions must maintain a record of all nuclear bursts that have occurred in areas of responsibility and interest. This nuclear burst record provides the commander and his staff with a clearing point for queries concerning yield, coordinates, time, and type (high air, low air, or surface) of nuclear bursts.

Section III. USE OF RADIOLOGICAL INTELLIGENCE

8. General

The complete capability for the evaluation of radiological contamination intelligence exists at division and higher commands. Subordinate units, however, evaluate radiological contamination intelligence and make maximum use of the intelligence derived from the division. Chapters 6 and 8 deal with the operational aspects and use of radiological contamination intelligence as applied to staffed headquarters.

9. Use of the Types of Intelligence

As a type of radiological contamination intelligence, fallout predictions are only estimates and are used for considering possible effects of the contamination hazard. Radiological contamination overlays, however, depict the actual contamination situation and their use involves calculation of probable doses of radiation absorbed or to be absorbed by personnel operating in the contaminated area, estimation of resulting casualties, and estimation of effect of casualties on accomplishment of the mission. Procedures for these dose calculation and casualty estimates are contained in chapter 6. Use of each of the types of radiological intelligence is discussed below.

a. Prestrike and poststrike fallout predictions provide a reasonable assurance that no significant hazard will occur outside the predicted area and that a significant hazard will occur somewhere inside the area. These predictions will not indicate the exact location or magnitude of the hazard within the predicted area but provide the commander and staff with

information from which to warn units of a possible hazard. With this information, the commander can consider the results of the undesirable effects of the hazard on the mission and make plans to minimize or eliminate these undesirable effects.

b. Prestrike fallout predictions warn the commander and staff of a hazard that may occur and enable them to provide for this possibility in estimates and planning.

c. Poststrike fallout predictions warn the commander and staff of a hazard that is developing. Movement of units to alternate positions and similar positive actions are not normally initiated based upon the poststrike prediction alone but are withheld until monitoring data are available. However, there will be times when such movement is justified. The poststrike prediction may also be used to plan the detailed collection effort for the radiological contamination overlay preparation as prescribed by local SOP.

d. Radiological contamination overlays provide the commander and staff with intelligence sufficiently detailed and reliable to allow estimation of the effect on mission and operations of a contamination hazard already present and to select courses of action that minimize or avoid the effects of the hazard.

e. A record of all nuclear bursts that have occurred in areas of responsibility and interest provides the commander and his staff with a clearing point for queries concerning yield, coordinates, time, and type (high air, low air, or surface) of nuclear bursts (par. 17e).

Section IV. BACKGROUND KNOWLEDGE

10. General

The collection of radiological information and the effective use of the resulting intelligence depend to a large degree upon adequate understanding by commanders and individuals at all levels of the following aspects of large-area radiological contamination.

11. The Contaminated Area

The radioactive material in a contaminated area is assumed to be spread essentially evenly over the ground. An individual standing in a level portion of a contaminated area will thus be receiving radiation from all directions. However, because of absorption by the air, and other factors, essentially all radiation the individual receives comes from a circular area 100 meters in radius around his location. About half the radiation the individual receives comes from a circular area 10 meters in radius around his location. These factors affect the evaluation of contamination hazards and decisions such as the selection of sites for improvised or prepared shelters, the location of survey meters for monitoring, and the selection of routes of passage through the contaminated area.

a. The Fallout Area. Fallout areas will be the largest of the contaminated areas; most of the operational impact of contaminated areas will come from fallout. One aspect of fallout which is of particular importance is that the direction toward which fallout will go from ground zero will have little or no relation to surface wind direction.

- (1) *Fallout self-warning.* The rapid onset of fallout, especially from small yields, within a few kilometers of ground zero of a surface burst requires that personnel in the vicinity take precautionary measures consistent with their mission. The time after burst before onset of fallout near ground zero may vary from about 1 to 20 minutes depending on the yield of the weapon. Self-warning is achieved by assuming observed nuclear bursts to be fallout producing until the passage of time proves otherwise. During the period of uncertainty, precautionary

measures consistent with the mission are instituted. See FM 21-41 and FM 21-40 for information on appropriate precautionary measures.

- (2) *Physical recognition of fallout.* Fallout particles are often visible during hours of daylight. The arrival and deposition of dustlike particles after a nuclear burst occurs should be assumed to indicate the onset of fallout unless monitoring shows no radiation in the area.

b. The Neutron-Induced Area. Neutron-induced contamination is expected to be operationally significant only when friendly elements will be required to pass through or occupy positions in the immediate vicinity of ground zero. Even for many of these situations, the significance of the induced areas will be reduced for the following reasons:

- (1) *Obstacles.* In wooded or urban areas, the detonation of a nuclear weapon can produce other collateral effects such as tree blowdown, rubble, and fire. These collateral effects can create obstacles which would delay or even prevent the passage of troops through the area of attack. The area over which these obstacles can occur is normally many times greater than the area of induced activity. The obstacle area may frequently be so located and be of such size as to require the commander to adopt a scheme of maneuver which avoids the ground zero area entirely. In such cases, the hazards of induced activity would be overshadowed by the obstacle problem.
- (2) *Time factor.* The induced activity produced by a friendly nuclear attack, especially on an enemy rear-area target will generally undergo considerable decay prior to the arrival of friendly troops. If the planned time of arrival in the target area is after 1 to 1½ days following the attack, the induced activity is not a hazard to foot troops required to cross the area. Furthermore, after H + 5 days, the induced activity will have decayed

to such an extent that the area can be occupied for an extended period of time without risk.

- (3) *Area affected.* For tactical weapons, the maximum expected diameter of an area of induced activity is only about 2,200 meters and will usually be much smaller. In this induced activity area, only a relatively small circle of no more than a 300-meter radius around ground zero is a hazard to early passage of troops on foot or in unarmored vehicles.

12. Decay of Contamination

The dose rate at any location within a contaminated area does not remain constant but reduces slowly, or decays with time. Thus, a contamination hazard will decay with time until it is no longer of military significance. Furthermore, the rate at which this decay takes place will also vary with time, generally becoming slower as time passes. The decay rate for contamination in an area depends upon many factors but is generally predictable or can be determined.

13. Radiac Instruments

Radiac instruments measure gamma radiation without regard to its source and the dose or dose rate measured may represent gamma radiation from fallout, radiological agents, induced radioactivity, or combinations of these. The radioactive material from these contamination sources produces both beta and gamma radiation. However, only the gamma hazard will be significant if the proper protective measures are taken by exposed personnel (FM 21-41).

14. Transmission Factors

a. Ground Dose Rate. The ground (outside) dose rate is the unshielded dose rate measured 1 meter above ground level (about waist high). This dose rate approximates the average whole body dose rate a man would receive if he were standing in the open in a contaminated area. Ground dose rates are the basic reference used to describe the magnitude of a contamination hazard. All dose rates mentioned in radiologi-

cal intelligence are ground dose rates unless otherwise specified. Thus, all dose-rate information obtained under conditions which would modify the ground dose rate must be converted to ground dose rates for radiological intelligence purposes.

b. Factors Affecting Determinations of Ground Dose Rates. Radiation is received from all directions in a contaminated area. Inside a vehicle or shelter this radiation is partially shielded out and a measured dose rate is lower than the ground dose rate at this location. The degree of shielding depends on the type of vehicle or the construction of the shelter and not on location within the contaminated area. Similarly, dose rates measured in an aircraft flying over a contaminated area are lower than the corresponding ground dose rates because of the shielding effect of the air and the aircraft.

c. Use of Transmission Factors. A transmission factor (TF) is a measure of the degree of shielding afforded by a structure, vehicle, or fortification, or by a set of specified shielding conditions. The transmission factor is that fraction of the outside (ground) dose or dose rate which is received inside the shielding object.

Thus:

Transmission factor =

$$\frac{\text{Inside dose or dose rate}}{\text{Outside dose or dose rate}} \text{ or } TF =$$

$\frac{ID}{OD}$; and, by mathematical rearrangement:

$$ID = TF \times OD \text{ and } OD = \frac{ID}{TF}.$$

d. Determination of Transmission Factors. Transmission factors for common types of vehicles, structures, or fortifications are contained in figure 19. These transmission factors assume the shielded dose or dose rate to be measured at approximately the center of the shielded volume. Transmission factors determined in the field require two dose-rate readings taken about the same time; one will be an outside (ground) dose-rate reading and the other an inside (shielded) dose-rate reading. The transmission factor can then be calculated, using the formula in *c* above.

CHAPTER 2

NUCLEAR BURST DATA

Section I. NUCLEAR BURST REPORTING

15. General

The final location of fallout is primarily dependent on the heights from which the fallout particles start their descent and the wind structure between the ground and the various portions of the nuclear cloud during the period of fall of these particles. The heights from which the fallout particles start their descent are dependent upon the total yield of the fallout-producing nuclear burst. Thus, since the yield is determined from nuclear burst information, the reliability of the prediction depends to a great extent on the upper air wind data and the nuclear burst information available.

16. The Nuclear Burst Report

a. Need. The nuclear burst report provides information (or data from which the information can be derived) essential to commanders and staffs at all echelons for estimates of the situation and for fallout prediction (par. 19a).

b. Reporting. The Nuclear, Biological, Chemical formats (NBC) are devised for reporting nuclear, biological, and chemical attacks and follow Standardization Agreement (STANAG) 2103. Only that portion which pertains to nuclear burst reporting (NBC 1) is presented in this chapter. Nuclear burst data are reported through intermediate headquarters to the CBRE by the most expeditious means available in the form of nuclear burst reports (NBC 1) as shown below.

Type of Report: NBC 1.

B. Position of Observer.

C. Azimuth of Attack from Observer. (Report magnetic azimuth of observer to cloud center or mushroom stem; measure in mils or degrees state which.)

D. Date and Time of Attack in Greenwich Civil Time (ZULU).

E. Illumination Time. (Report under conditions of poor visibility when cloud measurements cannot be made; report in seconds.)

F. Location of Attack. (Report observed or known coordinates on this line; if this line is reported, omit C.)

H. Type of burst (air, surface, or unknown). (This line must be reported.)

J. Flash-To-Bang Time (seconds).

L. Nuclear Burst Cloud Width. (Measure when bang is heard; report in mils or degrees, state which.)

M. Stabilized Cloud-top Angle and/or Cloud-bottom Angle. (Measure at H + 10 minutes; report in mils or degrees, state which. Report *Top* or *Bottom* with appropriate angle.)

c. Special Instructions. The following instructions apply when making a nuclear burst report:

(1) Transmit available data promptly.

(a) Transmit all data except line M immediately after bang time.

(b) Transmit line M immediately after measurement of the angles. Also, include lines B and D with this report.

(2) Transmit only those lines of the format for which data are available.

(3) Transmit line E only when observation is limited and cloud measurements cannot be obtained.

d. Example Nuclear Burst Reports. The following are examples of nuclear burst reports as received at a CBRE. Example data are

shown below, following the format shown in b above, as the data would be reported by an observer.

Sample of First Nuclear Burst Report

NBC 1
B. ET054066
C. 182 mils
D. 090907Z
H. Surface
J. 23 seconds
L. 110 mils

Sample of Second Nuclear Burst Report

NBC 1
B. ET054066
D. 090907Z
M. 800 mils Top
550 mils Bottom

e. Responsibilities. Collection of nuclear burst report data and submission of nuclear reports are command responsibilities. Staff responsibilities vary, however, depending on whether the attack is friendly or enemy.

(1) *Friendly nuclear attack.*

(a) The major command containing the delivery unit which fires a nuclear weapon is responsible for submitting a nuclear burst report if the burst is a surface burst (intentional or accidental). This report is transmitted through normal communications channels to the fire support element (FSE) which provides the information to the CBRE.

(b) Information about nonsurface friendly nuclear bursts is provided to the CBRE by the FSE as required.

(2) *Enemy nuclear attack.*

(a) All units will submit a nuclear burst report for every observed nuclear burst unless the burst is known to be friendly. Unit commanders should designate specific individuals to be responsible for the collection of nuclear burst report data; those who use compasses and angle measuring devices in normal mission functions, such as observers and gun crews, should be designated.

(b) Reports on nuclear attacks are transmitted from the observing

units to the FSE or G2, using command, intelligence, or artillery channels as appropriate. The FSE or G2 then forwards the information to the CBRE.

17. Sequence of Events

The most probable sequence of events and the recommended field procedures for the observer gathering nuclear burst report data are as follows:

a. Daytime Burst.

- (1) Hit the ground at the flash, estimate the elapsed time, and time the balance of the flash-to-bang time. Enter data as line J.
- (2) Measure the nuclear burst cloud width immediately after the bang is heard (passage of shock wave). Enter data as line L. Measure the azimuth to the stem or nuclear burst cloud center. Enter data as line C.
- (3) Complete lines B, D, and H and submit first nuclear burst report (NBC 1).
- (4) Measure the stabilized cloud parameters 10 minutes after the burst and enter data as line M.
- (5) Submit second nuclear burst report (NBC 1), including lines B and D.

b. Nighttime Burst or When Visibility is Poor.

- (1) Hit the ground at the flash and estimate the elapsed time of illumination; estimate the balance of the flash-to-bang time. Enter data as lines E and J.
- (2) Measure the azimuth to the stem or nuclear burst cloud center as soon as possible after the bang is heard. Enter data as line C.
- (3) Complete lines B, D, and H.
- (4) Submit nuclear burst report (NBC 1).

18. Estimation Techniques

A detailed explanation of lines E, H, J, L, and M of the nuclear burst report is contained in paragraphs 20 through 28 with techniques for determining nuclear burst report data for

these line items and for determining nuclear burst information from them. Instruments are used to obtain nuclear burst report data whenever possible, although field expedient methods may be used if necessary (par. 22).

19. Nuclear Burst Information

a. Requirements.

- (1) *Estimates of the situation.* The essential nuclear burst information required for estimates of the situation is location of ground zero (GZ), total yield, and time of burst.
- (2) *Fallout predictions.* The essential nuclear burst information required for the preparation of either a detailed fallout prediction or a simplified fallout prediction is location of ground zero, total yield, and time of burst. Nuclear burst information used to prepare fallout predictions for enemy bursts is derived from nuclear burst

reports submitted by units observing the burst. Nuclear burst information used to prepare fallout predictions for friendly bursts is obtained from the command which directs the firing of the weapon. Nuclear burst reports may also be received for friendly bursts from units that had not received warning.

b. *Special Nuclear Burst Information.* The size of the fallout area is dependent in part upon height of burst (HOB) and fission yield-total yield (FY/TY) ratio. The target analyst in the FSE can provide these two factors for fallout predictions of planned surface bursts. The FY/TY ratio can be obtained from the target analyst for friendly bursts which inadvertently produce fallout. For enemy bursts, no means of estimating HOB and FY/TY ratio are available. Thus, for enemy bursts, no correction for these two factors is made in preparation of fallout predictions in the field army.

Section II. FIELD EXPEDIENT METHODS FOR NUCLEAR YIELD ESTIMATION

20. General

a. Nuclear burst reports must be obtained in order to provide information for determining location of ground zero and for estimating yield. Units in the vicinity of the burst will take required measurements and transmit the information as nuclear burst reports through higher headquarters to the nearest CBRE.

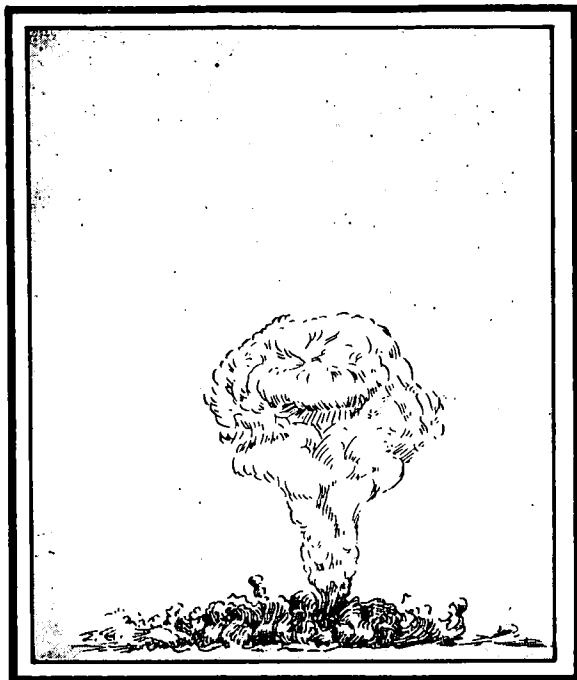
b. It is unlikely that any one unit will be in a position to obtain all the information specified in the nuclear burst report format of paragraph 16b; however, units should strive to ascertain and report as much of the data as possible.

21. Explanation of Terms

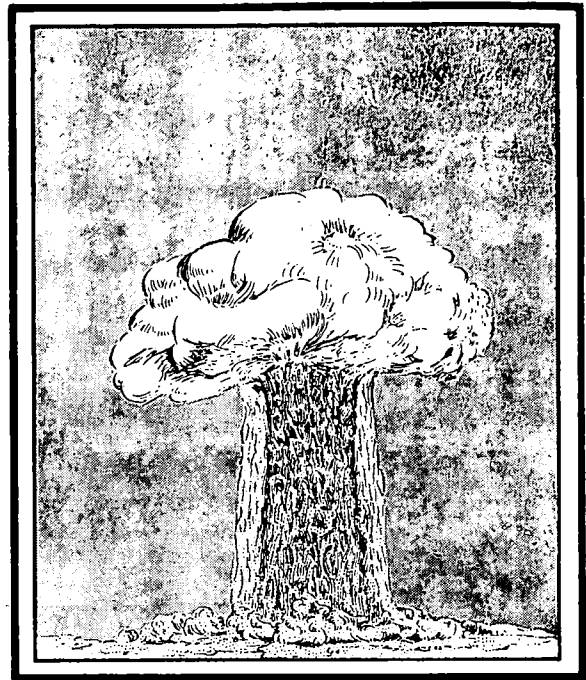
a. *Development of nuclear clouds* is divided into three stages for the purpose of yield estimation. The *fireball stage* exists from the instant of detonation until the generally spherical cloud of explosion products ceases to radiate a brilliant light. During this stage the fireball must not be observed because the very brilliant light is capable of causing permanent damage to the eyes. As the brilliant light fades into a

dull reddish glow, the fireball stage transforms into the *nuclear burst cloud stage*. The nuclear burst cloud stage begins when the light of the fireball has faded to the point that the cloud from the explosion can be safely observed by the unprotected eye. At this time the nuclear burst cloud may be seen as either a spherical cloud (high airburst) or a mushroom type cloud (low air or surface burst). Severe turbulence and rapid growth in height and width are characteristics of this stage of development. This nuclear burst cloud stage continues until the cloud ceases to grow in height (stabilizes in height) although the width may continue to increase. Height stabilization occurs about 7 minutes after the explosion, regardless of yield. When the cloud ceases to grow in height (about $H + 7$ minutes), the *stabilized cloud stage* begins and continues as long as the cloud is detectable. The orderly sequence of development of the cloud formation phases of a typical low air nuclear burst (fireball to nuclear burst cloud to stabilized cloud) is illustrated in figure 3.

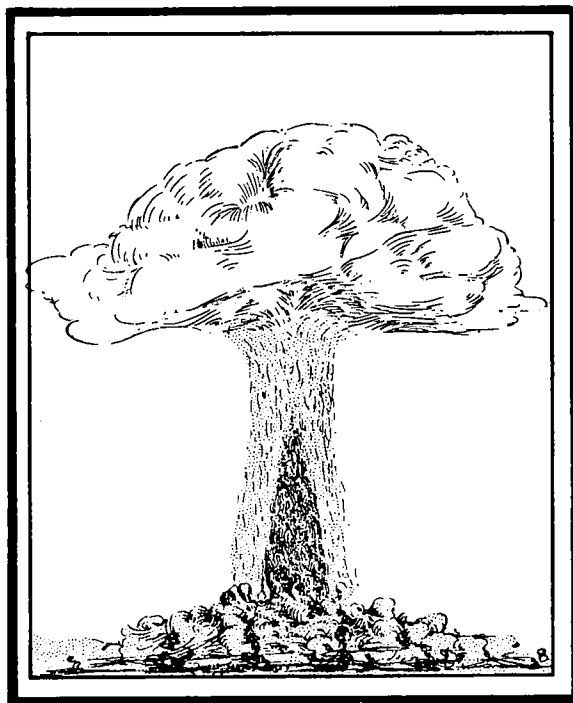
b. *Flash-to-bang time* is the time interval in seconds between the "blue-white flash" of the



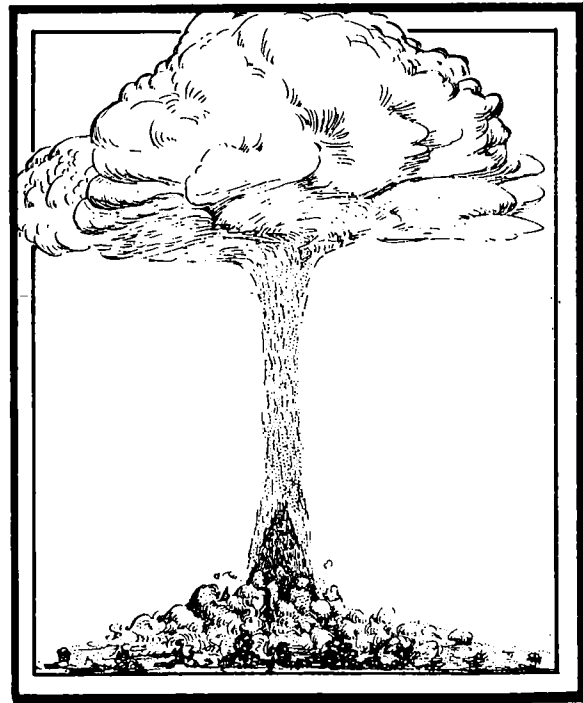
10 seconds after burst



1 minute after burst



5 minutes after burst



Stabilized cloud (7 to 10 minutes after burst)

Figure 3. Cloud development of a typical low air nuclear burst.

detonation and the arrival of the sound of the explosion at the position of an observer. The sound of the explosion (bang) travels at an average velocity of 350 meters per second. The distance in meters from an observer to ground zero can be estimated by multiplying the flash-to-bang time in seconds by 350; this distance can be read in kilometers directly from the right scale of figure 7.

Note. As a safety measure, the observer will stay on the ground or in cover until the arrival of the sound of the explosion (bang). The observer will be estimating or measuring the time after the flash during this flash-to-bang time. No cloud measurements are made until after the bang is heard. Individuals ignoring this warning may be subjected to severe blast effects.

c. *Width of the Nuclear burst cloud* is the angular dimension in mils of the nuclear burst cloud diameter as measured by an observer immediately after the passage of the sound of the explosion (bang). In the field, this measurement is made by the observer who will take cover on noting the flash and count or measure the seconds until the explosion is heard (flash-to-bang time); he will then proceed to measure the nuclear burst cloud width by available means. If optical instruments are not available for precise measurements, the observer should resort to field means, such as mil-calibrated fingers or hands (par. 22). At this time there is no danger to the eyes from the fireball luminescence. It is important that the measurement of the width of the nuclear burst cloud be made immediately after the bang is heard because the rapid expansion of the nuclear cloud would cause a later reading to be in error.

d. *Azimuth from the observer to the mushroom stem or cloud center* is measured and reported to assist higher headquarters and the CBRE in locating ground zero (par. 24a) of the burst and to assist small units in locating ground zero when the simplified fallout predictor is used. Measure azimuth immediately after measurement of the nuclear burst cloud mil width.

e. *Cloud angles are discussed below:*

- (1) *Stabilized cloud-top angle* is the vertical angle in mils or degrees measured from ground zero or the horizon plane to the top of the stabilized cloud. This measurement is made approximately 10 minutes after the burst (fig. 4).

- (2) *Stabilized cloud-bottom angle* is the vertical angle in mils or degrees measured from ground zero or the horizon plane to the point of intersection of the stabilized cloud and the stem. This measurement is made approximately 10 minutes after the burst (fig. 4).

f. *Illumination time* is the interval of time between the instant of detonation and the cessation of the brilliant light of the explosion during the fireball stage of the nuclear cloud development.

g. *Height of burst* refers to the position of the nuclear burst relative to the surface (earth or water). The exact height of burst of enemy-delivered nuclear bursts is desirable to know but may be virtually impossible to ascertain with present observational techniques. The trained observer can, however, discriminate between the obvious airburst and the contact surface burst, and leave the transition zone as an area of doubt to be resolved by other means such as the presence or the absence of a crater.

h. *Ground zero* is that point on the ground at which the nuclear explosion occurs. Should the nuclear burst occur either in the air or underground, ground zero is the point on the surface directly beneath or above the explosion.

22. Field Expedient Measurement of Angles

When optical instruments are not available for measurement of angle as required for the determination of burst parameters described in the preceding paragraphs, these angles can be estimated in mils or degrees by holding the arm fully extended and measuring the angle in terms of the hand, fist, or a number of fingers, as described in FM 6-40 and illustrated in figure 5.

23. Nuclear Burst Report

A format for transmission of nuclear burst information to higher headquarters and the CBRE is discussed in paragraphs 15 through 19. Angular measurements will normally be reported in mils; if angles are reported in degrees, then specify degrees.

24. Ground Zero Location

a. *Intersection of Azimuths.* The location of

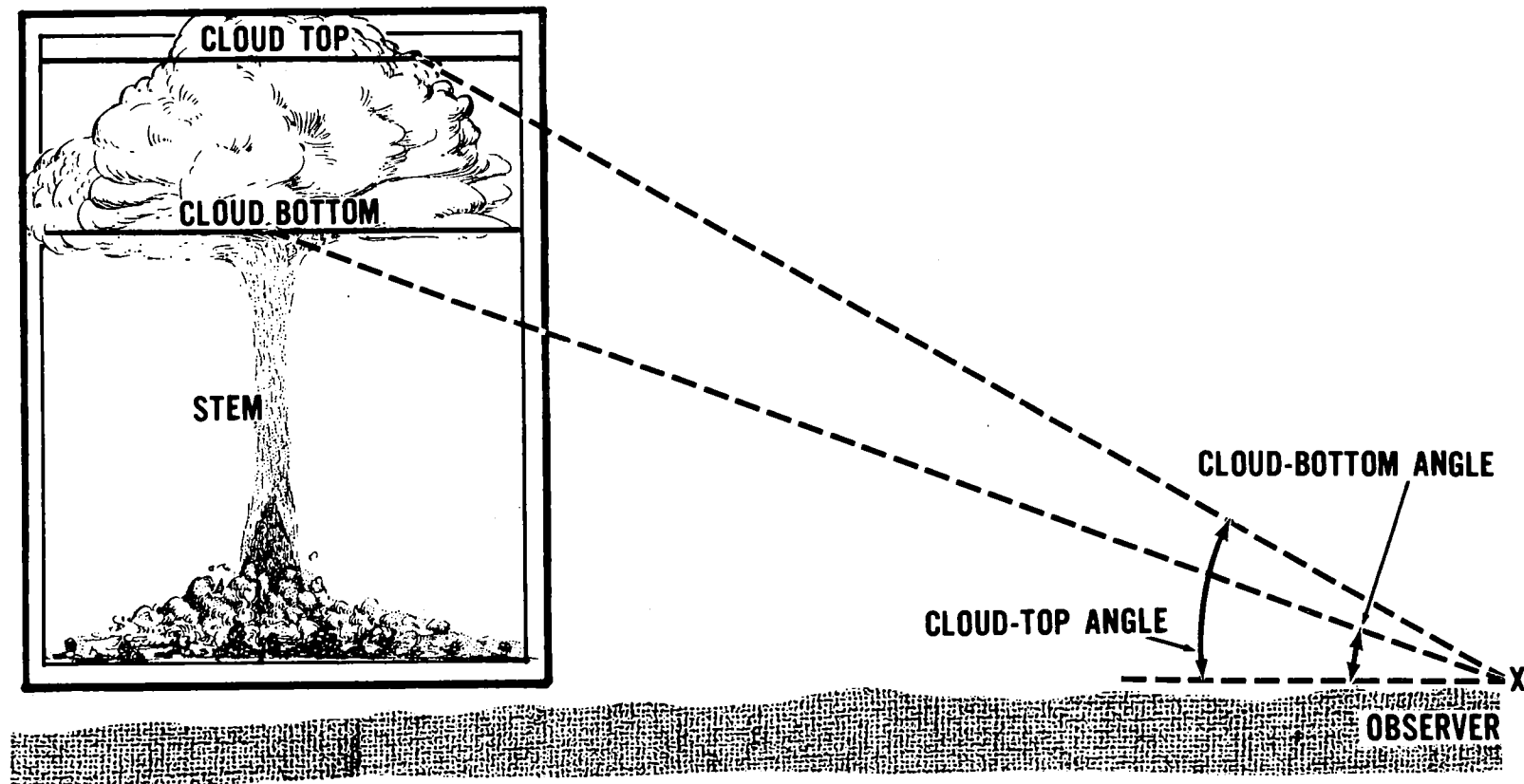


Figure 4. Stabilized nuclear burst cloud (low airburst).

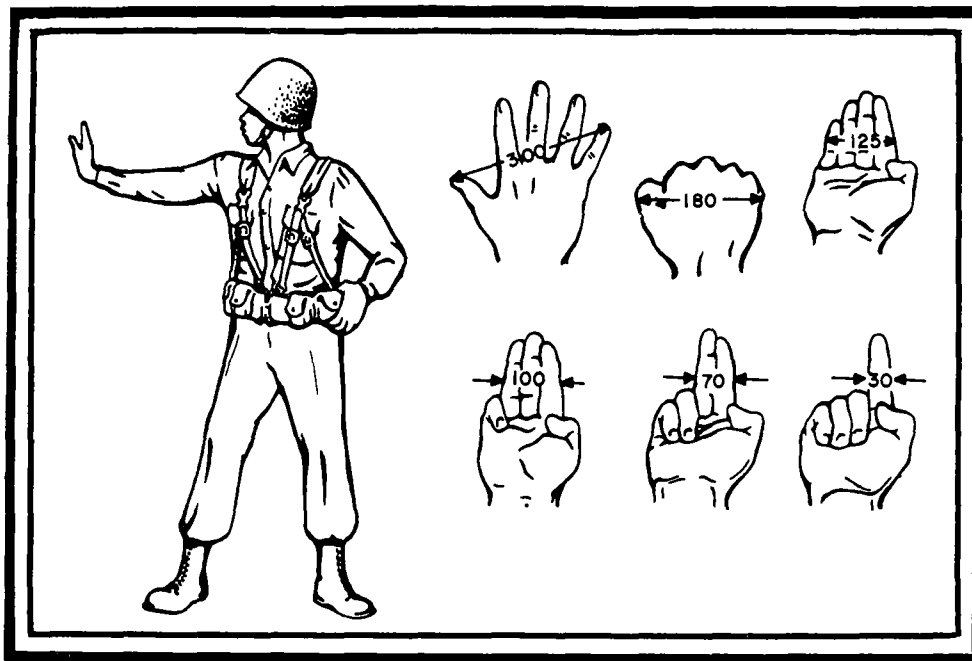


Figure 5. Examples of measuring angles with the hand.

ground zero can be determined by intersecting azimuths from two or more observation points; intersecting arcs with radii of flash-to-bang distances from two or more observation points; or by azimuth and flash-to-bang distance from one observation point. Ground zero is normally located by the intersection of azimuths from two or more observation points.

b. Direct Observation. Units may be able to ascertain location of ground zero of very small nuclear explosions by direct observation and should report coordinates of ground zero in the nuclear burst report.

c. Observer Location. The location of the observer is necessary for determination of ground zero and coordinates of the observer must be reported. Generally, units reporting large nuclear explosions will be from 10 to 50 kilometers (km) from ground zero and should report flash-to-bang time, observer location, and azimuths to the nuclear burst cloud along with the other items specified in the nuclear burst report.

25. Nuclear Burst Parameters for Yield Estimation

a. General. Nuclear burst parameters have

been correlated with yield and are presented in nomograms, each of which is an independent means of determining an estimated yield. If any of the following combinations of burst parameters are known, an estimated yield can be determined from the nomograms:

- (1) Flash-to-bang time and width of nuclear burst cloud.
- (2) Flash-to-bang time and stabilized cloud-top angle.
- (3) Flash-to-bang time and stabilized cloud-bottom angle.

b. Nuclear Burst Cloud Mil Width.

- (1) Figure 6 is used to determine yield from nuclear burst cloud width and flash-to-bang time. The right-hand scale is the nuclear burst cloud width in mils, the center scale is the flash-to-bang time in seconds, and the left-hand scale is the yield in kilotons (KT).
- (2) To use figure 6 place a hairline from the point on the right-hand scale representing the nuclear burst cloud width through the point on the center scale representing flash-to-bang time.

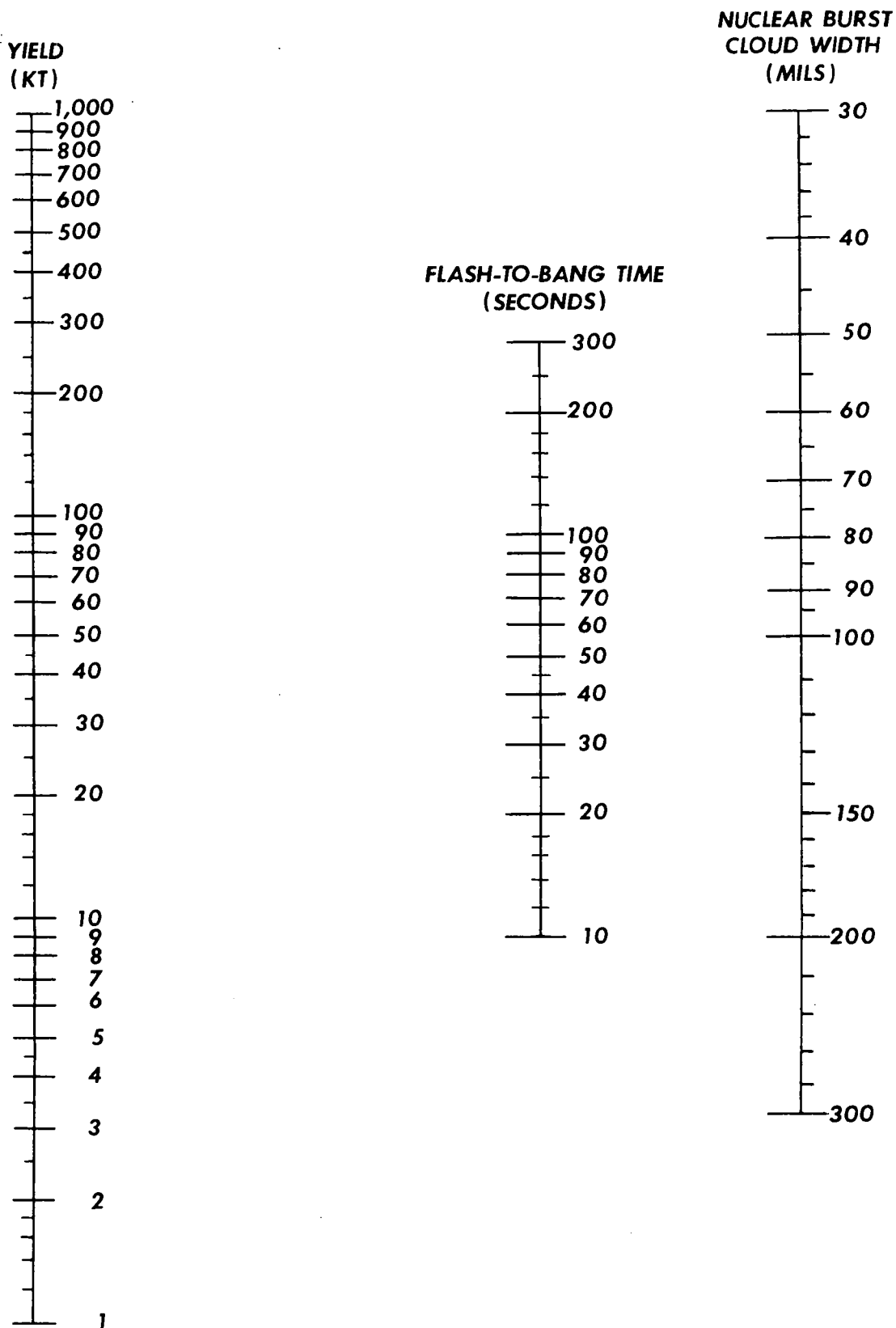


Figure 6. Yield estimation (flash-to-bang time versus nuclear burst cloud mil width).

At the point of intersection of the hairline and the left-hand scale, read the yield.

- (3) For example, an observer reports a flash-to-bang time of 60 seconds and a nuclear burst cloud width of 100 mils. To estimate the corresponding yield by using the nomograms, connect 100 mils on the right-hand scale and 60 seconds on the center scale with a hairline; at the point of intersection of the hairline and the left-hand scale, read a yield of about 60 KT.

c. Stabilized Cloud-Top Angle or Cloud-Bottom Angle.

- (1) Figure 7 is used to determine yield from flash-to-bang time and either stabilized cloud-top angle or stabilized cloud-bottom angle measurements. The right-hand scale gives the flash-to-bang time in seconds on the right side and distance in kilometers to ground zero on the left side. The center scale is the cloud-top angle or cloud-bottom angle, measured in mils on the left of the scale and in degrees on the right of the scale. The left-hand scale is actually two scales. On the left of the left-hand scale are listed the yields to be read when using the stabilized cloud-top angle measurements; on the right of this left-hand scale are listed the yields to be read when using the stabilized cloud-bottom angle measurements.
- (2) To use figure 7, place a hairline through the point on the right-hand scale representing flash-to-bang time and through a point on the center scale representing either the cloud-top angle measurement or the cloud-bottom angle measurement. At the point of intersection of the hairline and the left-hand scale, read the yield. If a cloud-top angle measurement is used on the center scale, read the yield on the left side of the left-hand scale entitled, Yield (Cloud Top). If a cloud-bottom angle measurement is used, read the yield on the right side of the left-hand scale entitled, Yield (Cloud Bottom).

- (3) For example, an observer reports a flash-to-bang time of 120 seconds, angle to cloud top of 300 mils, and angle to cloud bottom of 200 mils. Place a hairline from 120 seconds on the flash-to-bang time scale through 300 mils on the left or upper side of the angle scale; the yield is read as 30 KT on the left side (cloud top) of the yield scale. Place a hairline from 120 seconds on the flash-to-bang time scale through 200 mils on the left side of the angle scale; the yield is read as 23 KT on the right side (cloud bottom) of the yield scale.

26. Illumination Time

a. As a field expedient, yield may be estimated from the measurement of the illumination time of a nuclear burst, especially during hours of darkness. Techniques for measuring illumination time will vary, depending on the situation, but under *no circumstances* should the observer attempt to look directly at the fireball since this can result in permanent damage to the eyes. The illumination time may be estimated by the observer who has taken shelter in a foxhole by noting the light reflected into the foxhole. The observer can look at the floor of the foxhole and still sense the duration of the flash or reflected light. Counting in seconds will probably be the most effective way of determining the illumination time since the "dazzle" (flash blindness) effect will preclude the reading of watches.

b. The data below shows rough estimations of yield, using illumination time:

<i>Illumination time seconds</i>	<i>Yield KT</i>
less than 1	1
1	4
2	15
3	35
4	60
5	100
6	150
7	200
8	250
9	300
10	400
12	600
14	750
16	1,000

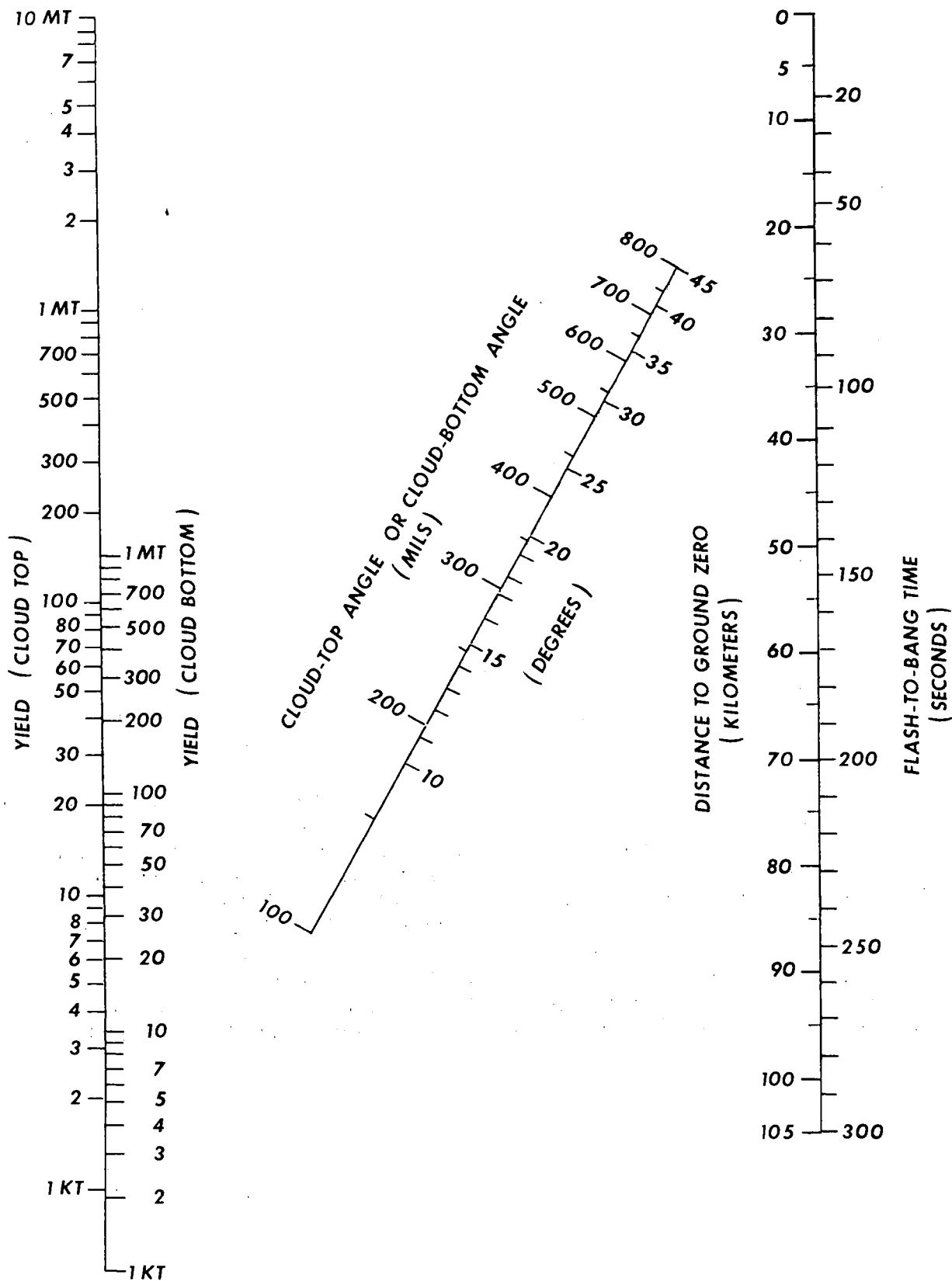


Figure 7. Yield estimation (flash-to-bang time versus stabilized cloud-top angle or stabilized cloud-bottom angle).

27. Nuclear Yield Calculator

a. *General.* The M4 nuclear yield calculator, a component part of the M28 Nuclear Calculator Set, is designed to provide the field commander with a rapid method for calculating nuclear yield from a nuclear burst. The calculator permits estimation of yield when the illumination time is known and when the flash-to-bang time (or distance from burst) and any one of the following parameters are known:

- (1) Stabilized cloud-top vertical angle.
- (2) Stabilized cloud-bottom vertical angle.
- (3) Nuclear burst cloud width.

b. *Description.* The M4 nuclear yield calculator consists of three plastic discs imprinted with logarithmic scales and instructions for use. The inner disc is made of opaque laminated white plastic; the two smaller outer discs are made of transparent plastic. The outer discs are mounted concentrically on the sides of the inner disc by means of a metal rivet which permits them to rotate freely about the inner disc.

- (1) *Inner (white) disc.* The inner disc is imprinted on both sides, as follows:
 - (a) *Face of disc.* Yield-stabilized cloud bottom scale, yield-stabilized cloud top scale, and a stabilized cloud-bottom or cloud-top angle scale.
 - (b) *Reverse side of disc.* Yield scale, fireball illumination time scale, and nuclear burst cloud width at bang time scale.
- (2) *Outer (transparent) discs.* The two outer discs are imprinted as follows:
 - (a) *Front disc.* Flash-to-bang time scale, calculator nomenclature, indexing pointer, and instructions.
 - (b) *Back disc.* Combined flash-to-bang

time and distance to burst scale, indexing pointer, and instructions.

c. *Use.* Calculations are made by alining known values on the nuclear burst parameter scales and reading the calculated yield on the yield scale under the indexing pointer. The scales on the front of the calculator permit calculations of yield when the flash-to-bang time and the angle of either the cloud top or cloud bottom are known. The scales on the back of the calculator permit calculations of yield when the flash-to-bang time and the width of the nuclear burst cloud are known; fireball illumination time is also correlated to yield on the back. For detailed example problems, see TB CLM 92.

28. Training

a. *Individual Training.* Unit commanders will insure that selected individuals are trained in field expedient methods of determining ground zero location, type of burst, angular elevation of the top and bottom of the stabilized cloud, and the width of the nuclear burst cloud. In addition, all individuals will be trained to such a level that they have a basic understanding of fallout hazards and protective measures. Refer to FM 21-41 for further information on individual training.

b. *Unit Training.* Nuclear burst situations will be integrated into unit training exercises. Standing operating procedures will contain instructions on actions to be taken when units observe nuclear bursts. Refer to FM 21-40 and FM 21-48 for further information on unit training. Training Film 3-3139, Nuclear Yield Estimation, Field Expedient Methods, may be used in unit training to illustrate space-time method of nuclear yield estimation and field expedient methods of measuring angles.

CHAPTER 3

RADIOLOGICAL MONITORING

Section I. INTRODUCTION

29. General

Radiological monitoring is the use of radiac instruments to determine the presence and amount of radiological contamination. The radiac instrument used in monitoring radiologically contaminated areas is the area survey meter. No special organization is required for monitoring.

30. Operational Value of Monitoring

Monitoring is included in normal intelligence and reconnaissance activities. Monitoring does not interfere with the performance of the primary mission of the personnel designated as monitors. This is in contrast to radiological survey which requires that personnel be diverted from their primary mission. Monitoring provides the following:

a. Warning. Monitoring provides warning of a hazard that otherwise might go undetected. For example, monitoring alerts the command to the arrival of fallout or alerts

units on the move when they contact a contaminated area.

b. Unit Radiological Information.

- (1) *Small units.* Unit monitors keep the unit commander informed of the degree of radiological hazard in his unit area.
- (2) *Brigade, battalion, and comparable units.* Monitoring reports from subordinate units are used in conjunction with fallout predictions in developing radiological intelligence.
- (3) *Division and higher or similar organizations.* Monitoring reports, screened by intermediate headquarters, are one of the forms of information used by major organizations having area responsibilities in developing the CBR (radiological) contamination overlay. If sufficient data are collected from monitoring and if reports are not delayed in transmission, a radiological survey may not be required.

Section II. AREA MONITORING

31. General

Under nuclear warfare conditions, company/battery units (or smaller units operating independently) monitor for radiation. Monitoring may be either periodic or continuous. Units monitor continuously under conditions listed in paragraph 32b; otherwise, periodic monitoring is performed.

32. Types of Monitoring

a. Periodic Monitoring. Periodic monitoring is the periodic check of unit areas for radiation. The purpose of periodic monitoring is to

assure the commander that his unit area is not contaminated and to warn him if contamination arrives. Periodic monitoring requires that the monitor turn on the area survey meter at selected times and check the unit area for radiation, using the monitoring techniques outlined in paragraph 33; the frequency of monitoring readings is specified by the unit SOP. Units having several area survey meters on hand may need to use only one instrument for this purpose.

b. Continuous Monitoring. Continuous monitoring is a continuous surveillance for radiation in the unit area of operations or along a

route of march and is performed by units, using the techniques established in paragraph 33. Continuous monitoring requires that the monitor have the survey meter with him and turned on at all times; the frequency of readings will depend upon the current situation. For example, the monitor will take more frequent readings when fallout is actually arriving on the unit position than he will if the unit is simply warned that it may be in the fallout area. Units initiate continuous monitoring in the following situations:

- (1) When a fallout warning is received.
- (2) When ordered by the unit commander.
- (3) After a nuclear blast has been heard.
- (4) When the unit is moving.
- (5) When a nuclear strike is observed or reported.
- (6) During reconnaissance and patrol activities.
- (7) When radiation above 1 rad/hr is detected by periodic monitoring.

33. Monitoring Techniques

Monitoring techniques vary, depending upon such factors as ground dose rate, operational or tactical conditions, dose status of monitor, type of area survey meter, and whether the monitor is stationary or moving. The technique used must provide sufficient information to allow evaluating agencies to calculate the ground dose rate at the monitor's location. A form devised for recording data is described in paragraph 43.

a. Direct Technique. The direct determination of ground dose rate is the simplest and most precise of the monitoring techniques. The unshielded ground (outside) dose rate may be determined directly by standing at the desired location, holding an area survey meter waist high, and observing the dose-rate reading. The preferred procedure is to take readings in the open at least 10 meters away from buildings, other large structures, or objects that may shield out a portion of the radiation. If there are points of operational interest where this procedure cannot be used, additional readings can be taken at those points. Thus, if a road through a narrow cut or defile is of operational interest, readings should be taken both in the open near the cut and in the cut. In cities or built-up areas, readings are taken in the center

of the streets or at street intersections. When readings are taken in locations where structures or objects may partially shield the readings, the monitor points the survey meter in all directions and records the highest reading. In all these cases no correlation factor data (par. 34) are required since the readings are representative of the area of interest. Safety considerations may preclude the direct determination of ground dose rates except in low dose-rate areas, while obtaining ground dose rate transmission factor data, while monitoring for the initial detection of contamination, or while moving on foot.

b. Indirect Technique.

- (1) *Monitoring inside shelters.* Within the contaminated area, monitoring will normally be performed from within shelters or fortifications. The monitoring reading is obtained by noting the dose rate when the survey meter is held in the correct location within the shelter.

(a) In shelters for which transmission factors are published, the correct location for the survey meter is the approximate center of the volume inclosed by the shelter.

(b) In shelters for which transmission factors are not published, location for the survey meter must be the same as was used for the shielded dose-rate measurement of the transmission factor data (par. 34).

- (2) *Monitoring by mounted personnel.* Monitors mounted in ground or aerial vehicles use the ground or aerial survey procedures established in chapter 4 to obtain monitoring information.

34. Correlation Factor Data

a. Requirement. All monitoring reports, except those made using the direct technique of paragraph 33a, must include correlation factor information so that shielded dose rates can be converted to ground dose rates. Identification of the type of structure is sufficient for monitoring reports of readings obtained in shelters for which transmission/correlation factors are published; the published transmission/correlation factors will be used for processing the

reports. Correlation factor data are required for processing monitoring readings obtained in shelters for which transmission/correlation factors are not published.

b. Procedure. The correlation factor data required consist of two dose-rate determinations which must be made within 1 to 3 minutes of each other. One is a direct determination of ground dose rate made at a location 10 meters from the shelter (par. 33a), if possible, unless the shelter is underground. The other is a reading made with the survey meter held at the correct location inside the shelter (par. 33b). This location should be away from the inside walls with the only restriction being that the survey meter must be held in this same location for all subsequent monitoring readings made within the shelter (par. 33b(1)(b)). If outside dose rates are necessary prior to completion of fallout, use of published correlation factors and inside dose-rate readings will provide an estimation.

c. Example. A company monitor is located in a shelter dug into the side of a hill; the area is not contaminated. Since there is no published, transmission/correlation factor for a shelter of this type, he has selected a spot outside the shelter at which to read the ground dose rate and another location inside the dug-out for inside dose-rate readings. A nuclear burst occurs several kilometers away and about 30 minutes later the monitor detects the arrival of fallout. After the completion of fallout, the monitor takes a dose-rate reading of 2 rad/hr with the survey meter at the selected location inside the shelter and then goes immediately to the selected location outside the shelter and takes a ground dose-rate reading of 10 rad/hr. The two dose-rate readings were made within a few minutes of each other, so the correlation factor data for this shelter are:

Inside dose rate (*ID*) = 2 rad/hr.
Outside (ground) dose rate (*OD*) =
10 rad/hr.

The correlation factor is determined as shown below: -

$$\begin{aligned}\text{Correlation factor (CF)} &= \frac{OD}{ID} \\ &= \frac{10 \text{ rad/hr}}{2 \text{ rad/hr}} \\ &= 5.\end{aligned}$$

35. Personnel Requirements

The requirement for monitors is widespread throughout the Army because of the need for radiological information. Reconnaissance and intelligence agencies (including aerial observer personnel, scout platoons, scout sections, and patrols) monitor for radiation as a normal part of their mission. Command responsibilities for maintaining a monitoring capability are described in paragraph 7.

a. Individual Training. (See FM 21-41.) All Army personnel should be familiar with the basic capabilities and characteristics of radiac instruments. Selected personnel will be given specialized training as outlined in Army Subject Schedule 3-18.

b. Unit Training. (See FM 21-48 and FM 21-40.)

- (1) Unit SOP's will include monitoring procedures and measures for defense against radiological contamination.
- (2) Field exercises and CPX's will include fallout situations that require monitoring and reporting activities.
- (3) Army training tests will include situations that require units to conduct monitoring activities and employ appropriate measures for defense against radiological contamination.

36. Equipment Requirements

The equipment necessary for monitoring is listed below. Also, a dosimeter, such as radiacmeter IM-93, must be carried by the monitor if command requirements include tactical dose reports.

a. Area Radiological Survey Meter. The radiacmeter IM-174/PD (Standard A) is an area radiological survey meter that measures gamma radiation in the range of 0 to 500 rad/hr.

b. Watch. The monitor must have a means of determining the time, since time of reading is an essential part of a monitoring report.

c. Radiological Data Sheet. DA Form 1971-R (Radiological Data Sheet) (fig. 8), may be used for recording data (par. 43). This form may be reproduced locally if unavailable through normal channels.

37. Area Survey Meter Checks

a. Preoperational Check. Area survey meters are ion-chamber type radiac instruments. TM 11-6665-213-12 establishes a preoperational check to insure that the survey meter is functioning properly. It is imperative that this check be made each time the survey meter is turned on or whenever erratic readings are obtained during monitoring.

b. Zeroing. Ion-chamber type radiacmeters may be "zeroed" in a contaminated area. TM 11-6665-213-12 establishes procedures for this operation. It is essential that the area survey meter be zeroed before each set of monitoring readings. If this procedure is not followed, electronic fluctuations can cause significant errors in monitoring readings.

c. Contamination Check. It is probable that

the area survey meter will become contaminated while operating in a contaminated area. Dose-rate readings made with a contaminated survey meter will be considerably higher than the actual dose rates and would be less reliable. Therefore, it is essential that the area survey meter be kept free of dust during monitoring operations. If the area survey meter has a carrying case, meter contamination can be easily checked by removing the survey meter from the carrying case while observing the meter reading. If the dose rate drops significantly, the case is contaminated. If the area survey meter does not have a carrying case, the check can be made by wiping the instrument with a damp rag or by brushing. Whenever possible, monitoring data should be remeasured and corrected data reported if meter contamination is detected.

Section III. REPORTING AND RECORDING

38. General

The primary purposes of monitoring are to allow warning of all personnel of the arrival or presence of a radiological hazard and to provide a basis for prompt action by the commander to minimize the hazard.

39. Format for Monitoring Reports

a. Format. The format for monitoring reports follows the format established in STANAG 2103 (par. 16b). Only that portion (NBC 4) which pertains to monitoring reports is presented in this chapter. Monitoring reports contain the location of the reading; the dose-rate reading identified as contact, peak, shielded, or special, and correlation factor information, if shielded dose-rate readings are reported; and the date and time of the reading in Greenwich Civil Time (ZULU). The format for monitoring reports follows:

Type of report.

Q. Location of reading.

R. Dose rate. (Identify as contact, peak, shielded, or special; include correlation factor information, if shielded dose-rate readings are reported; report in rad/hr.)

S. Date and time of the reading in Greenwich Civil Time (ZULU).

Note. Letter items Q, R, and S may be repeated as often as necessary.

b. Sample Monitoring Report. A sample monitoring report as submitted by a monitor, following the format of *a* above, is shown below:

SAMPLE MONITORING REPORT NBC 4

Q. TU054066
R. 50 shielded (foxhole)
S. 161310Z
Q. TU056068
R. 70 peak
S. 161350Z

40. Automatic Reports

Proper functioning of the radiological contamination information collection effort requires that all units submit certain automatic monitoring reports. These reports provide the minimum essential monitoring information for warning, survey planning, and hazard evaluation purposes. Automatic reports are submitted through command or operational channels to the CBRE of the major command having area responsibility for the location in which the monitoring information was taken. For example, a corps unit located in a division area would submit monitoring reports to division.

Intermediate headquarters screen these reports and forward only those which are necessary to describe the radiological contamination hazard in areas of responsibility.

a. Contact Report. Warning units of approaching fallout or of previously undetected contamination is a primary step in avoiding casualties from contamination hazards. Fallout warning or contamination warning, to be meaningful, must be based upon information from units that initially contact the contamination hazard. A knowledge of the movement of the fallout arrival line is necessary for survey control, traffic control, and other activities. All units will submit contact reports under the following conditions:

- (1) Contact reports will be submitted with EMERGENCY precedence whenever an initial ground dose rate of 1 rad/hr or more is detected in an area not predicted to receive fallout. These reports will provide the basis for issuing fallout or contamination warnings throughout the major command. Intermediate headquarters will screen and evaluate these reports and reduce the precedence if the hazard has already been detected and reported.
- (2) Contact reports will be submitted by units located in fallout warning areas whenever the ground dose rate builds up to 5 rad/hr.

b. Peak Dose-Rate Report. At locations receiving fallout, the dose rate will steadily rise until it reaches a peak and then will decrease as the contamination decays. Units will report this peak dose rate or in the event the area survey meter goes off scale, they will report when the area survey meter comes back on scale after peaking.

c. Special Reports. SOP's or other standing instructions may establish special automatic reports. These special reports are for evaluation by CBRE of the contamination hazard for the purpose of inviting command attention to areas of serious concern. Since the operational situation, dose status, and similar considerations determine the criteria for these special reports, they are not specified in this manual. The bases for reports of this type may be as follows:

- (1) When the ground dose rate goes above a specified value. *Example.* The radiation dose status of subordinate units and other conditions for an operation are such that areas where dose rates are above 50 rad/hr will be of serious concern. Thus, automatic monitoring reports will be required when the ground dose rate goes above 50 rad/hr.
- (2) After a specified period of time.

41. Other Reports

Other reports on a nonautomatic basis may be required to properly evaluate a radiological contamination hazard. Requirements for these reports are established by directives, SOP's, or other standing instructions that include report basis, precedence, reporting procedure, format, and communications channels. Examples of these reports are as follows:

- a.* A series of 5 or 6 monitoring reports at 30-minute intervals from selected units for H-hour and decay-rate determinations.
- b.* Summary reports of the radiological contamination in specified areas of responsibility.
- c.* Verification reports at specified locations.

42. Communications

a. Automatic Contact Report.

- (1) The contact report described in paragraph 40a is forwarded as indicated by the the most expeditious means of communication available.
- (2) A warning will be broadcast over an appropriate warning net by major commands upon verification of fallout occurring or detection of previously unreported radiological contamination that poses a hazard to personnel.

b. Special Automatic Reports. Headquarters below division level specify communications for automatic reports originating in their areas of responsibility. Artillery units use artillery nets or the area communications system. The highest precedence should be used consistent with other communication and operational requirements.

RADIOLOGICAL DATA SHEET MONITORING AND POINT TECHNIQUE (FM 3-12)					DATE 5 JUNE 1962		PAGE NO. 1		NO. OF PAGES 1	
SURVEY PARTY OR MONITORING UNIT DESIGNATION ALPHA-ONE					MONITOR (Print name) CPL JAMES JONES					
MAP USED GERMANY SHEET 252 1:50,000					TYPE OF VEHICLE OR OTHER SHIELDING APC			INSTRUMENT TYPE IM-174/PD		
READ- ING NO.	LOCATION	TIME	DOSE RATE (rad/hr)	DO NOT USE ¹	READ- ING NO.	LOCATION	TIME	DOSE RATE (rad/hr)	DO NOT USE ¹	
1	NV188797	0900	6	NOT	16					
2	"	0915	PEAK 17	266	17					
3	"	0945	14	218	18					
4	"	1015	12	188	19					
5					20					
6					21					
7					22					
8					23					
9					24					
10					25					
11					26					
12					27					
13					28					
14					29					
15					30					
REMARKS H-HOUR = 0730 $\eta = 0.8$ $CF = \frac{60}{6} = 10$ $NF(0915) = 1.56$ $OCF = 10 \times 1.56 = 15.6$										
CORRELATION FACTOR DATA										
LOCATION	READ- ING NO.	DOSE RATE (rad/hr)		CF ¹	LOCATION	READ- ING NO.	DOSE RATE (rad/hr)		CF ¹	
		INSIDE	OUTSIDE				INSIDE	OUTSIDE		
NV188797	1	6	60	10						

¹ DO NOT USE. For control party use only.

DA FORM 1971-R, 1 JAN 63

Replaces DA Form 1971-R, 1 Nov 58, which is obsolete.

Figure 8. Completed radiological data sheet (monitoring).

c. *Other Reports.* Directions establishing these reports will specify communications channels and precedence.

43. Recording

The radiological data sheet (par. 36c) is designed for recording radiological data obtained by monitoring and survey. Space is provided on the front of the form for monitoring data and for survey data when the point or preselected dose rate techniques are used. Instructions for use of the back of the form are given in paragraphs 62 and 71. Headings provided in blocks are self-explanatory; in using

the form, any heading not applicable to the situation may be lined through by the monitor. Space is provided for use of the control party, as indicated, for entry of the correlation factor and normalized data. The REMARKS block is to be used by the monitor in providing any additional information which will be of value to the control party; this block is also to be used by the control party to enter time of burst and to show computations of the normalizing factors (NF) and the overall correction factors (OCF). A completed radiological data sheet, showing monitoring data and computations, is illustrated in figure 8.

Section IV. MONITORING OF PERSONNEL, FOOD, WATER, AND EQUIPMENT

44. General

a. *Radiacmeters for Monitoring Personnel, Food, Water, and Equipment.* Standard Army radiacmeters to be used in monitoring personnel, food, water, and equipment are equipped with separate probes and earphones to facilitate monitoring. The monitor can retain control of the probe as it is placed near the surfaces and also hear the change in clicks from the instrument when contamination is encountered.

b. *Acceptable or Safe Levels of Contamination.* Acceptable or safe levels of remaining radioactive contamination must be established by the commander on recommendation of the medical officer.

45. Monitoring of Personnel

When operational areas are contaminated, personnel monitoring stations should be established as soon as practicable and all personnel leaving the contaminated areas should be monitored. Personnel who are contaminated will be required to decontaminate themselves. Personnel monitoring is performed to detect contamination on the body and thus serves as a guide for decontamination procedures to be used to prevent entry of contamination into the body. Monitoring for radioactive contamination on personnel is very slow and difficult. Proper monitoring of personnel consists of the selection and correct use of proper instruments; complete and careful checking of those parts of the body and clothing most susceptible to

contamination (hands, face, shoes, sleeves, and trousers); and the use of a systematic monitoring procedure, that is, monitoring the hands first, working up to the face and head, then proceeding down the body to the shoes.

a. The probe window of the radiacmeter should be held 2 to 3 centimeters (cm) from the surface being monitored for beta-gamma contamination. The probe should be moved along the surface with a slow, steady motion in proceeding with (1) through (4) below. The person being monitored should stand straight on a step-off pad, or on the controlled side of a line or barrier, with feet spread apart about 30 cm (1 foot) and arms extended side-ward with palms up and fingers straight.

- (1) Monitor both hands and forearms to the elbows with palms up, then repeat with hand and arms turned over.
- (2) Monitor the entire front of the body, starting at the top of the head; monitor the forehead, nose, lips, neckline, torso, knees, and ankles carefully.
- (3) Repeat the monitoring from head to ankles from the back.
- (4) Monitor the sole of each foot.

b. Personnel with wounds should be monitored by medical personnel or under the supervision of medical personnel.

46. Monitoring of Food

a. Except in rare cases of induced radiation, rations in cans or other sealed containers are not in danger of radiological contamination.

As the contamination will normally be limited to the outer surface of the sealed containers, decontamination is accomplished by washing and scrubbing the outer surface. Under no condition should sealed containers be opened until they have been decontaminated and the effectiveness of decontamination established.

b. Food not protected in sealed containers must be suspected of contamination until monitored. Potatoes and hard-skinned fruits and vegetables can be decontaminated by washing or scrubbing, followed by peeling or scraping and washing again. Remove meats and fish from the contaminated area to a clean area. Brush off all visible dirt; washing is not recommended. Monitor meat or fish with an AN/PDR-27J radiacmeter, or similar G-M instrument, with the probe open and held approximately 1 centimeter from the surface of the food. If the reading is in excess of 0.1 millirad per hour, then the food must be decontaminated. A thin layer of meat can be pared and the food remonitored. A reduction in dose rate would indicate that the contamination was confined to the surface of the food. The paring or cutting away process can be continued, within practical limits, until the dose-rate reading is less than 0.1 millirad per hour. If initially or after paring is accomplished the dose rate is less than 0.1 millirad per hour the food can be safely consumed. As prepared food in open containers will probably be thoroughly contaminated, dispose of by burial or as otherwise determined by designated personnel of the Army Medical Service.

c. Any food which has been exposed to radioactive contamination must be carefully monitored before and after decontamination. Foods in which radioactivity has been induced can only be decontaminated by aging. Careful monitoring will determine the progress of radioactive decay during aging.

47. Monitoring of Water

a. Decontamination of water is a responsibility of the Corps of Engineers. Approval of the potability of water is a responsibility of the Army Medical Service.

b. Radioactive contaminants in water are not affected by boiling or by other water treatment methods designed for chemical or biological decontamination.

c. It is better to use ground water in preference to surface water. If it becomes necessary to use contaminated water, the instructions set forth below should be followed and the water used only under these conditions.

- (1) In division and corps area during combat, if the external radiation hazard permits unsheltered occupancy of the water point, the water is suitable for consumption during a period of occupancy not exceeding one week.
- (2) An AN/PDR-27J radiacmeter, or similar G-M instrument, may be utilized (probe open and held approximately 1 centimeter from the surface of the water) to give a qualitative indication of beta-gamma contamination. However, to make a quantitative determination of the actual level of contamination, water samples must be sent to a laboratory equipped to make such measurements. Based on laboratory findings, the medical officer may indicate appropriate periods for consumption.

d. IN AN EMERGENCY ONLY, water from a moving stream or similar source may be used, even though it contains radioactive contamination, if it is filtered through a 6-inch column of loose dirt and subsequently boiled or treated with iodine water purification tablets or calcium hypochlorite to kill biological contaminants.

48. Monitoring of Equipment

a. Equipment which has been exposed to radiation or has been in a contaminated area must be monitored. This should be performed at an equipment monitoring station as near the contaminated area as possible. Equipment that is found to be contaminated should remain within a restricted area until the contamination is removed or has become militarily insignificant from aging. In general, care should be taken when monitoring equipment to pay particular attention to those surfaces where the contamination is most likely to occur, such as the wheels, tires, and undersides of vehicles and aircraft, greasy surfaces, floors, and steps. Information obtained by monitoring equipment

from a contaminated area is a valuable guide in determining the method of decontamination to be used.

b. The probe window of the radiacmeter should be held about 2 to 3 cm from the surface being monitored for beta-gamma contamination. The probe should be moved along the surface with a slow steady motion.

49. Contamination of Radiacmeters

a. When monitoring for high levels of con-

tamination, a low level of instrument contamination can be tolerated. The instrument may still be used by noting the reading due to contamination and subtracting this reading from surface readings.

b. Contamination of the radiactmeter may be determined by removing the instrument from the contaminated area and checking the reading; any reading other than background would normally be due to contamination of the instrument.

CHAPTER 4

RADIOLOGICAL SURVEY

Section I. INTRODUCTION

50. General

Radiological survey is the use of area survey meters in an organized effort to determine the degree and extent of radiological contamination on the ground. A radiological survey is performed by a group comprised of a control party and one or more CBR teams. The control party, consisting of one or more men, plans and directs the radiological survey and screens and transmits the data to the authority that ordered the survey. Normally, the control party will be located at battalion or higher level; in some situations establishment of control parties at company level may be required. The survey party, organized within the company/battery CBR team, consists of a monitor and necessary support and security personnel.

51. Operational Value of Survey

At division and higher echelons, monitoring reports may not provide sufficient information for evaluation of contaminated areas. Surveys may be necessary to provide the essential information. Surveys should be conducted only when the essential information cannot be obtained from monitoring reports and other sources because personnel required to conduct the survey, and for support, must be diverted from their primary duties.

52. Survey Control Methods

The primary method of survey control is a centralized operation in which the authority ordering the survey provides the control party and the radiological data is reported direct to the control party. For example, if division orders an aerial survey, the CBRE will act as the control party. Data are not screened, consolidated, or evaluated at intermediate head-

quarters. The alternate method of control is a decentralized operation directed through command channels and controlled by a subordinate command which furnishes the radiological data to the authority ordering the survey. An aerial survey is normally carried out by the primary control method; a ground survey may be carried out by either the primary control method or the alternate control method, depending upon the operational requirements, span of control, and communications capabilities.

53. Radiation Safety

An operation exposure guide for nuclear radiation is specified by the commander who ordered the survey. The CBR team is notified of the operation exposure guide for the survey.

54. Airborne Radioactivity

Most contaminated particles in a radioactive cloud rise to considerable heights; thus, fallout may extend over an appreciable time and area. A survey conducted before fallout is complete in an area is not accurate because contaminants are still suspended in the air. The survey may however, indicate the general direction and approximate extent of fallout; the survey could be conducted as a hasty aerial survey and made as part of a tactical damage assessment flight. The hazard to survey personnel and possible contamination of aircraft should not be overlooked in considering conduct of a survey before fallout is complete. These two factors may be particularly significant in the immediate vicinity of ground zero at times less than $H + 1$.

55. Coordination

Wherever practicable, the control party will coordinate the activities of the CBR teams with

the units located in the area to be surveyed. If coordination by the control party is impractical due to communications failure or other cause, the CBR teams will be informed that coordina-

tion has not been effected. The CBR teams will be directed to effect coordination provided the situation in the area and the required time of completion of the survey permit.

Section II. AERIAL RADIOLOGICAL SURVEY

56. General

Radiological contamination information can be obtained by use of the radiacmeter IM-174/PD in rotary-wing or fixed-wing aircraft. Since aerial surveys are conducted rapidly and at a distance from the radiation source, the aerial survey party would be exposed to considerably less nuclear radiation than a ground survey party if an equivalent ground survey were conducted over the same area. Thus, aerial surveys can be employed over areas that have dose rates unacceptably dangerous to ground survey parties. Because of speed and flexibility, aerial surveys can be employed to advantage over large areas, over unoccupied areas of operational concern, and over areas of difficult accessibility to ground troops. Aerial survey is preferable when conducting surveys of large areas. The advantages of aerial survey over ground survey are speed and flexibility of employment; lower radiation doses to survey party members; and minimum requirements for equipment, personnel, and communications.

57. Hasty Aerial Survey

Battlefield conditions or the operational situation may preclude the preparation of the detailed radiological contamination overlay and a hasty radiological contamination overlay may then be needed to satisfy the commander's requirements. A hasty aerial survey will normally be required to complete the overlay.

a. Purpose. The hasty aerial radiological survey is designed to provide the minimum essential information for evaluating the contamination hazard. The minimum essential information is that required to determine the outer limits of the area of militarily significant contamination (par. 117c), a few peak dose rates in the most heavily contaminated parts of the area, and dose rates at points of operational interest. The hasty survey must be accomplished and the information provided as

soon as possible after the contamination is on the ground.

b. Techniques. The techniques of conducting hasty aerial surveys are the same as for detailed aerial surveys (par. 58), with the following procedural exceptions:

- (1) The hasty survey requires considerably less detail than the detailed survey.
- (2) The hasty survey may cover only those parts of the contaminated area which are of immediate operational concern.
- (3) The hasty survey is not preplanned by the control party but is planned by the aerial survey party after arriving over the area; that is, the survey party selects the check points, routes, and course legs.
- (4) A debriefing is held by the control party after the hasty survey is performed.

58. Detailed Aerial Survey

Hasty aerial survey information and monitoring reports do not normally provide sufficient information for the preparation of the detailed radiological contamination overlay and a detailed aerial survey is usually required.

a. Planning. The basis for planning an aerial survey is the check point overlay. Check points that are easily identified from the air (small bodies of water, streams, or road junctions) are selected for the entire area of responsibility of the major command in advance by the chemical officer in coordination with the aviation officer. These check points are maintained as an overlay by these two staff officers. Then, when a survey requirement is established, the control party selects a series of course legs, routes, and points where data will provide sufficient ground dose-rate information to evaluate the contaminated area. Figure 9 illustrates a division area with selected check points, and

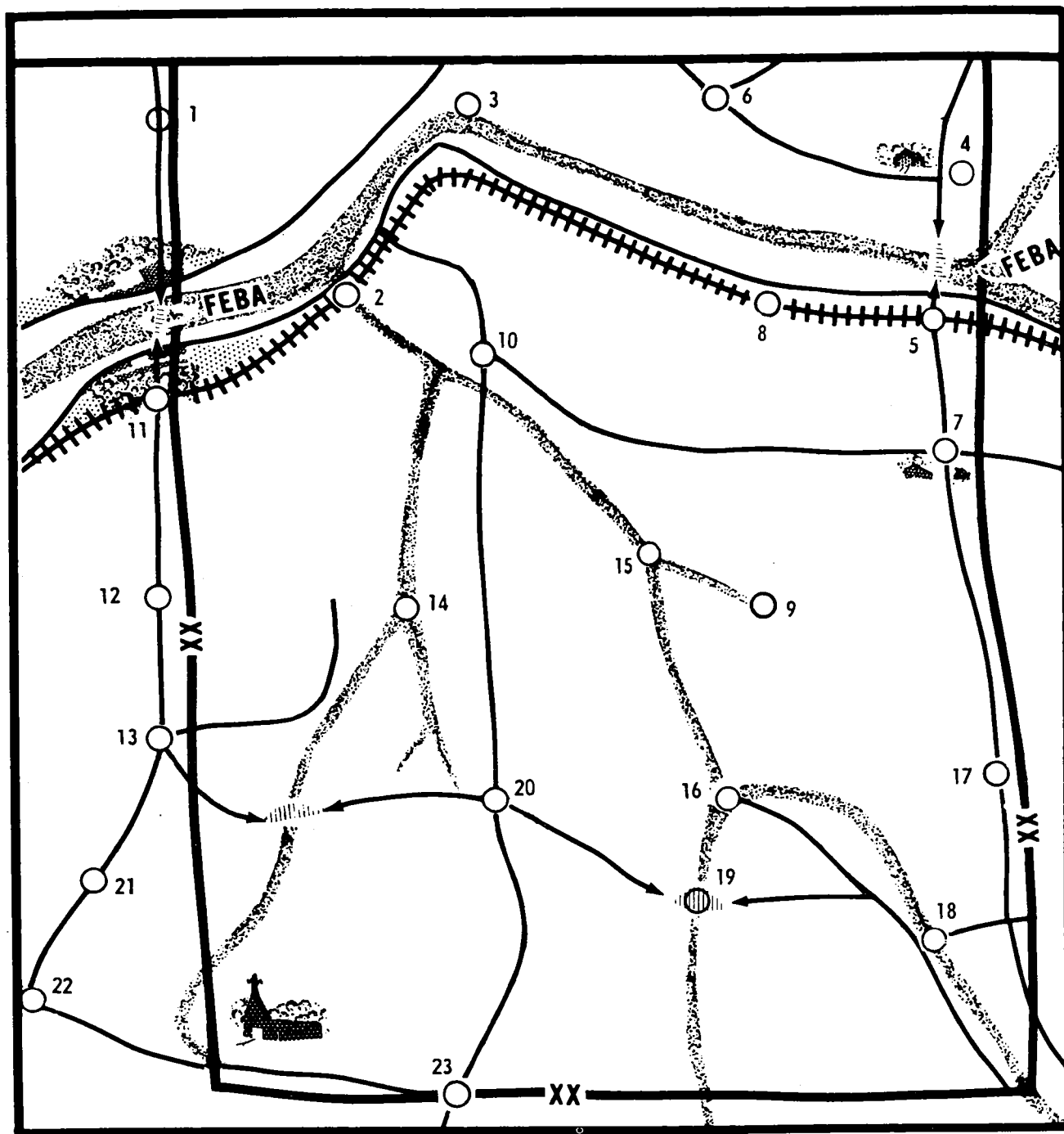


Figure 9. Sketch map of division area, showing preselected check points.

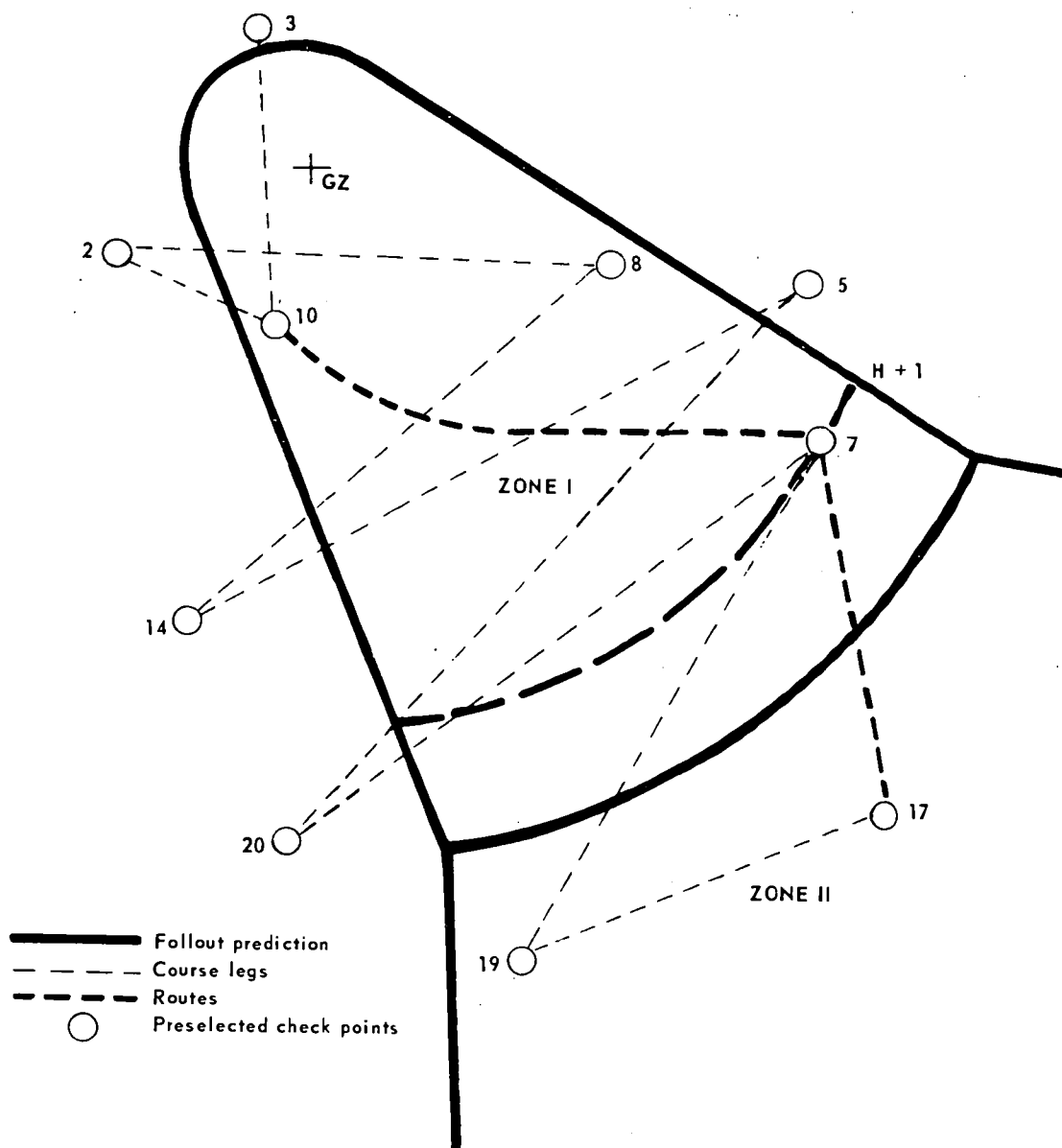


Figure 10. Fallout prediction and planned aerial survey.

figure 10 shows a plan for an aerial survey after a surface burst occurred in the vicinity. For further details on survey planning, see chapter 8.

b. Techniques. The techniques used to conduct detailed aerial surveys include: (1) the route technique; (2) the course leg technique; and (3) the point technique. In using the route technique, the pilot flies between 2 check points following the route of some predominant ter-

rain feature such as a road which connects the 2 check points (heavy dashed lines, fig. 10). In using the course leg technique, the pilot flies a straight line course (course leg) between 2 check points (thin dashed lines, fig. 10). The procedure followed in obtaining dose-rate information between check points is the same, using either the route technique or the course leg technique. When the dose-rate information obtained from use of either technique is proc-

essed, the result is a series of ground dose rates spaced at equal-distance intervals along the path over which the aircraft was flown. The point technique is used to determine the ground dose rate at points of operational concern and is normally employed to obtain more precise dose-rate information at those points than can be obtained by use of other techniques. Processed data from dose-rate information obtained using the point techniques are ground dose rates existing at each of the selected points. The course leg and point techniques are described in *c* and *d* below.

c. Procedures for Using Course Leg Technique. The course leg technique requires that the aerial survey party fly a straight line course (course leg) between two check points. The pilot maintains as nearly as possible a constant height above the ground, a constant ground speed, and a straight flight direction between the starting and ending check points of each course leg.

- (1) The pilot locates the starting check point of a course leg to be flown and either locates the end check point or determines the azimuth of the course leg.
- (2) The pilot flies the aircraft on the proper course to pass over the initial check point on a straight path to the end check point. When on course, he alerts the monitor and gives him the height above ground. Shortly before reaching the initial check point, the monitor records the time and height above ground. The monitor should check the survey meter before each course leg to assure proper operation.
- (3) The pilot commands "Mark" when the aircraft is directly over the starting check point at which time the monitor reads the survey meter, records the dose rate, and begins timing preselected time intervals.
- (4) The monitor reads the survey meter and records the dose rate at each preselected time interval (for example, every 15 seconds).
- (5) The pilot again warns the monitor when the aircraft approaches the end check point and when the aircraft is

directly over the end check point, the pilot commands "Mark." At this time the monitor reads and records the final dose rate for the course leg.

d. Procedure for Using Point Technique. Procedures for using the point technique vary according to the situation.

- (1) When the situation permits, the aircraft lands near the point of interest, the monitor dismounts, proceeds to the selected point and takes the reading by using normal ground monitoring procedures.
- (2) When the situation does not permit landing, the aircraft hovers over the selected point as close to the ground as possible. The monitor extends the survey meter as far outward and downward as possible to reduce shielding by the aircraft and takes the reading.
- (3) When the situation does not permit use of either of the above procedures, an estimation of ground dose rate may be made by use of an air-ground correlation factor and an aerial dose-rate reading (par. 60b).

59. Survey Meter Location in Aircraft

For each aerial survey a specific location within the aircraft must be selected for the survey meter. If air-ground correlation factor data are to be determined (par. 60a), the location of the survey meter may be as given in table I or may be selected for the convenience of the pilot and monitor with the restriction that all aerial survey readings must be taken with the survey meter in the selected location. If air-ground correlation factors from table II are to be used, the survey meter *must be* located within the aircraft as specified in table I.

Table I. Location of Survey Meter During Aerial Survey

Aircraft 1	Survey meter location
H-13	On the floor directly behind right cyclic stick.
H-23	On the floor in front of left seat between the cyclic stick and the antitorque pedals.

Table I. Location of Survey Meter During Aerial Survey—Continued

Aircraft ¹	Survey meter location
HU-1	On the floor of the passenger compartment in front of the second seat from the left side of the aircraft.
H-19	On the floor of the passenger compartment in front of the seat at station 136.
H-21	On the floor of the passenger compartment in front of the seat at station 299.
L-19	On the floor in front of the rear seat at station 61.
L-20	On the floor in front of right rear seat. ²
H-34	On the floor at station 100 directly over the forward center cell inspection plate. ²

¹ Order of preference of currently available aircraft for use in aerial survey is as listed.

² Air-ground correlation factor data are obtained with the instrument at this location, assuming that the fuel tank under this location is full and that no auxiliary fuel tanks are located between the meter and the contaminated area. If the fuel tank is not full, if it is in use while surveying, or if auxiliary fuel tanks interfere, the air-ground correlation factor data are not reliable.

60. Air-Ground Correlation Factors

An air-ground correlation factor is required for calculation of ground dose rates from aerial dose rates taken in an aircraft during a survey. The air-ground correlation factor (AGCF) is the ratio of a ground dose-rate reading to a reading taken at approximately the same time in an aircraft at survey height over the same point on the ground. There are two techniques for obtaining the air-ground correlation factor.

a. The preferred technique is by direct determination of ground dose rate during the survey and subsequent calculation of the air-ground correlation factor. The air-ground correlation factor may be calculated as shown below, using the aerial dose rate taken at survey height and the ground dose rate.

Ground dose rate (GR) = 100 rad/hr.

Aerial dose rate (AR) (100-foot altitude) = 40 rad/hr.

Air-ground

$$\begin{aligned}\text{correlation factor} &= \frac{GR}{AR} \\ &= \frac{100 \text{ rad/hr}}{40 \text{ rad/hr}} \\ &= 2.5.\end{aligned}$$

Then, by multiplying the reading taken in the aircraft at an altitude of 100 feet by the AGCF, the 1-meter above ground level reading can be estimated. The primary procedure for determining the ground dose-rate reading involves landing near the selected point. The monitor proceeds to that point and takes the ground dose-rate reading, using normal monitoring procedures. As a secondary procedure, the aircraft hovers as close to the ground as possible over the selected point while the monitor extends the survey meter as far outward and downward from the aircraft as possible before taking a reading to reduce shielding by the aircraft. Air-ground correlation factor data are obtained if possible for each 2 to 4 course legs or routes flown. The sites for obtaining air-ground correlation factor data should be selected to approximate average foliage and ground surface conditions in the contaminated area. Accuracy of this air-ground correlation factor data as to position, height above ground, and dose rate is of primary importance. New data must be obtained when survey height, ground foliage, or average ground surface conditions change significantly, or if the aircraft or the survey meter is changed.

b. When tactical considerations, terrain conditions, or high radiation dose rates do not permit the use of the preferred technique, the air-ground correlation factors shown in table II are used. To estimate a ground dose rate, multiply the aerial dose rate obtained by the correlation factor from table II for the type of aircraft and the height above ground at which the reading was taken. For example, while flying at a 500-foot altitude in an HU-1, a reading of 10 rad/hr is obtained; the air-ground correlation factor for an HU-1 and a height of 500 feet is 8.2.

Ground dose rate

$$\begin{aligned}&= \text{Aerial dose rate} \times \text{AGCF} \\ &= 10 \text{ rad/hr} \times 8.2 \\ &= 82.\end{aligned}$$

Table II. Air-Ground Correlation Factors (AGCF)

Height above ground (feet)	Aircraft						
	H-13 or HU-1	H-19	H-21	H-23	H-34	L-19	L-20
100	2.2	2.4	2.6	2.2	5.2	2.2	4.1
200	3.2	3.6	3.8	3.4	7.8	3.3	6.2
300	4.5	5.0	5.4	4.7	10.9	4.6	8.7
400	6.2	7.0	7.4	6.5	15.1	6.3	11.9
500	8.2	9.1	9.7	8.5	19.8	8.3	15.7
¹ 1,000	29	32	35	30	70	29	55
¹ 2,000	301	336	358	314	728	305	577
¹ 3,000	2,580	2,880	3,072	2,688	6,240	2,616	4,944

¹ The use of the AGCF with readings taken at these heights results in only an estimate of ground dose rates.

61. Capability of Aircraft

Light fixed-wing aircraft or helicopters are satisfactory for conducting aerial surveys; however, because of the slow speeds required, helicopters are the most desirable. Light fixed-wing aircraft and helicopters have approximately the same survey area coverage capability of between 130 and 450 square kilometers per hour per aircraft, depending upon the detail required and the degree of ground contamination. Order of preference of currently available aircraft for use in aerial surveys is contained in table I.

62. Recording and Reporting

a. Recording. The radiological data sheet, designed for recording data obtained by monitoring and survey (pars. 43 and 71), may be used for recording data obtained during aerial surveys. Data obtained, using the route or course leg technique, are recorded on the back of the radiological data sheet; data obtained by use of the point technique are recorded on the front of the form. Headings provided in blocks are self-explanatory; in using the form, any heading not applicable to the situation may be lined through by the monitor. Space is provided for use of the control party, as indicated, for entry of the air-ground correlation factor and normalized readings. The REMARKS block is to be used by the monitor in providing any additional information which will be of value to the control party; this block is also to be used by the control party to enter time of nuclear burst and computations of the air-ground correlation factor, normalizing factor,

and overall correction factor. A completed radiological data sheet, showing data collected by use of the course leg technique during aerial survey, is illustrated in figure 11.

b. Reporting. The survey data collected are delivered to the control party at the completion of each aircraft mission by physical drop, radio, or telephone from the nearest landing area. If communications equipment is available, the data may be transmitted by radio directly to the control party as the survey is being conducted.

63. Guidance for the Aerial Survey Party

The control party planning the aerial survey may not be completely familiar with the survey area or the current tactical or operational situation that exists there. However, the control party has ready access to the latest information available to the headquarters conducting the survey and provides guidance to the survey party at the briefing. In addition to information about the contaminated area, the control party provides the detailed aerial survey party with the identification of the course legs or routes to be flown and the approximate time periods during which groups of the course legs or routes are to be flown.

a. Survey Party Determinations. The aerial survey party determines as applicable:

- (1) The height above ground at which each course leg or route is to be flown.
- (2) The ground speed for each course leg or route.
- (3) The direction of flight for each course leg or route.

RADIOLOGICAL DATA SHEET ROUTE TECHNIQUE OR COURSE LEG TECHNIQUE (Ground and Aerial Survey) (FM 3-12)					DATE 5 JUNE 1962		PAGE NO. 1		NO. OF PAGES 1			
SURVEY PARTY DESIGNATION BRAVO-TWO					MONITOR (Print name) PFC PETER SMITH							
MAP USED GERMANY SHEET 252 1:50,000					AIRCRAFT OR VEHICLE TYPE H-23			INSTRUMENT TYPE IM-174/PD				
ROUTE OR COURSE LEG DESIGNATION CK-CE					DO NOT USE (For control party use only)		CE-BF		DO NOT USE (For control party use only)			
TIME AT START OF LEG OR ROUTE 0950							0955					
TIME ROUTE COMPLETED (Ground) OR SURVEY HEIGHT (Air) ¹ 200 FT							200 FT					
DISTANCE OR TIME INTERVAL USED 10 SEC							10 SEC					
REMARKS					READING NO.	DOSE RATE (rad/hr)	DO NOT USE party use only	READING NO.	DOSE RATE (rad/hr)	DO NOT USE party use only		
TIME OF BURST - 0730 AGCF = 3.8 $\eta = 0.8$ <u>CK-CE</u> NF = 1.96 OCF = $3.8 \times 1.96 = 7.64 = \underline{7.6}$ <u>CE-BF</u> NF = 2.01 OCF = $3.8 \times 2.01 = 7.84 = \underline{7.8}$ ¹Times of start and stop are reported for each route or portion of route completed at one time by ground survey. If a route is done in parts, use a separate column for each part. ²DO NOT USE. For control party use only.					1	12	91	1	2	16	1	
					2	12	91	2	2	16	2	
					3	11	84	3	2	16	3	
					4	11	84	4	3	23	4	
					5	10	76	5	3	23	5	
					6	9	68	6	3	23	6	
					7	8	61	7	3	23	7	
					8	7	53	8	4	31	8	
					9	6	46	9	4	31	9	
					10	5	38	10	5	39	10	
					11	5	38	11	5	39	11	
										12	5	38
AIR-GROUND OR VEHICLE CORRELATION FACTOR DATA					13	4	30	13				
LOCATION	HEIGHT (Feet) AIR ONLY	DOSE RATE (rad/hr)		CF ²	14	4	30	14				
		INSIDE AIR	OUTSIDE GROUND		15	3	23	15				
BF	200	5	19	3.8	16	3	23	16				
					17	2	15	17				
					18			18				
					19			19				

DA FORM 1971-1-R, 1 JAN 63 Replaces DA Form 1971-1-R, 1 Nov 58, which is obsolete.

Figure 11. Completed radiological data sheet (aerial survey).

- (4) The locations for determining air-ground correlation factor data.
- (5) The time intervals between readings.
- (6) Whether to delay the flight of a particular course leg or route.

b. Guidance. As a guide to the survey party in making the determinations in *a* above, the tactical, operational, and weather conditions existing at the time of survey and the dose condition of the survey party should be weighed against the following factors:

- (1) The slower the aircraft speed and the shorter the time interval between readings, the more accurate the results.
- (2) The unreliability of survey data obtained at heights of more than 500 feet above the ground. A height of 200 feet is considered optimum.
- (3) The slow response time of the IM-174/PD radiacmeter reduces reliability of the data obtained at ground speeds above 53 knots.
- (4) The combination of ground speed and

reading time interval should be selected so that the ground distance between readings is not more than 1,600 feet. For plotting accuracy, at least 10 readings between check points are desirable.

- (5) Air-ground correlation factor data should be taken where aerial and ground dose rates can be read most accurately on the survey meter. This will be where the dose rate taken in the air above the selected point is as close to 3 rad/hr as possible on the radiacmeter IM-174/PD.

64. Reliability

With the guidance and procedures outlined, aerial surveys provide the control party with adequate and sufficiently reliable data. Generally, the dose rate at a particular ground location, as determined by aerial survey, varies from the true dose rate at the location because of survey meter errors, pilot errors, monitor errors, and the overall system errors.

Section III. GROUND RADIOLOGICAL SURVEY

65. General

Radiological information can be obtained by use of the IM-174/PD by personnel mounted in wheeled or tracked vehicles. The information can also be obtained by personnel on foot but because of the high doses to personnel, foot surveys should be conducted only under exceptional circumstances. Armored vehicles reduce doses received by personnel and will be used whenever possible. Ground survey lacks the speed and flexibility of aerial survey; results in higher nuclear radiation doses to personnel; places a larger load on communications facilities; and requires diversion of more personnel and equipment from the mission. However, a ground survey is independent of weather conditions, can be conducted at night, and provides more accurate information than an aerial survey. All echelons can perform ground surveys within their areas of responsibility, using regularly assigned personnel and equipment.

66. Techniques

The techniques used to conduct ground surveys include: (1) the point technique; (2) the route technique; and (3) the preselected dose-rate technique.

a. Point Technique. In using the point technique, the ground dose rate is determined at a selected point of particular operational concern. The reading can be obtained by dismounting from the vehicle and taking a direct ground dose-rate reading or by taking the dose-rate reading inside the vehicle. If the dose rate is taken inside the vehicle, the ground dose rate will be determined by the control party by using a correlation factor (par. 70).

b. Route Technique. In using the route technique, dose-rate readings are taken inside the vehicle at selected distance intervals between check points along a designated route. If the vehicle does not have an odometer, the route is traversed at a constant speed and readings are taken at constant time intervals. Most

ground surveys are performed by use of the route technique.

c. Preselected Dose-Rate Technique. In using the preselected dose-rate technique, locations of preselected dose rates are determined along assigned routes. This technique is normally employed only for survey of old contamination or radiological agent contamination where the decay is very slow; dose rates and locations can be plotted directly without further processing.

67. Guidance for the Ground Survey Party

Normally, survey parties are briefed prior to conduct of the survey. This briefing may be centralized or conducted on an individual basis and may vary in detail from an area assignment to specific route and point assignments for each survey party. Basically, more general assignments facilitate the initiation of the survey, whereas the more specific assignments reduce security, communication, and interpretation difficulties. The degree of detail of the briefing depends upon the time available to plan the survey, the feasibility of a centralized briefing, and the status of training of survey party personnel.

68. Planning

The plan for the ground survey is similar to the aerial survey plan; that is, a series of routes and points are selected along which dose-rate data are obtained. Dose-rate readings are recorded and reported by the monitor of the survey party.

a. The preferred method is for the readings to be taken in the vehicle with the radiacmeter located in some position selected by the survey party. All readings taken and reported during the survey must be obtained with the survey meter at the selected position. The control party directing the survey then converts these inside readings to ground dose rates, using a correlation factor calculated from data provided by the survey party (par. 70).

b. For planning purposes, or when the situation does not permit the use of the preferred method as described in *a* above, published correlation factors (fig. 19) may be used by the control party for calculating ground dose rates. The location of the survey meter when published correlation factors are used will depend

upon the vehicle in which the survey meter is mounted (par. 69b).

69. Survey Meter Location in Vehicles

a. Most dose-rate readings taken during a ground survey by mounted personnel will be taken inside the vehicle and later converted to ground dose rates, using a correlation factor. For operational situations, it is preferred that correlation factor data be obtained by the survey party for use of the control party in calculating ground dose rates. The position of the survey meter should be as far from the sides, top, and floor of the vehicle as possible (fig. 12). The monitor should take the readings with the survey meter consistently located in the selected position.

b. When correlation factor data cannot be obtained by the survey party, published correlation factors may be used from figure 19. When these correlation factors are used to calculate the ground dose rate, the position of the survey meter *must* be as far from the sides, top, and floor of the vehicle as possible; the survey meter location *must* be the same for all readings taken (fig. 13).

70. Correlation Factor Data

a. Requirement. Correlation factor data are required in order to convert the reported readings taken inside the vehicle to ground dose rates existing outside the vehicle.

b. Providing Data. Data for the vehicle correlation factor are provided by the survey party and consist of a set of two readings taken at the same location. One reading is taken inside the vehicle with the instrument located in any convenient location but as far from the sides, top, and floor of the vehicle as possible. All subsequent inside readings reported for the survey must be taken with the meter in this same position. The other reading is taken immediately as a normal ground monitoring reading at the same location with the vehicle pulled away at least 10 meters. One or two additional sets of data should be taken at different locations so that the control party can use an average vehicle correlation factor. The sites for obtaining vehicle correlation factor data should be selected to approximate average foliage and ground surface conditions for the



Figure 12. Survey meter location (1/4-ton truck).

contaminated area. New data must be obtained if these conditions change significantly or if the survey meter or vehicle is changed. Accuracy of the correlation factor data is of paramount importance.

71. Recording and Reporting

a. Recording. The radiological data sheet (par. 75), designed for recording data obtained by monitoring and survey (par. 43), may be used for recording data obtained during ground survey. Data obtained, using the route technique,

are recorded on the back of the sheet. Data obtained, using the point or preselected dose-rate technique, are recorded on the front of the sheet. Instructions for completion are as given in paragraphs 43 and 62, marking through headings and entering information in the REMARKS block, as appropriate.

b. Reporting. Data from ground surveys are reported from the survey party to the control party of the authority directing the survey as rapidly as possible without screening or evaluation by intermediate headquarters. The re-

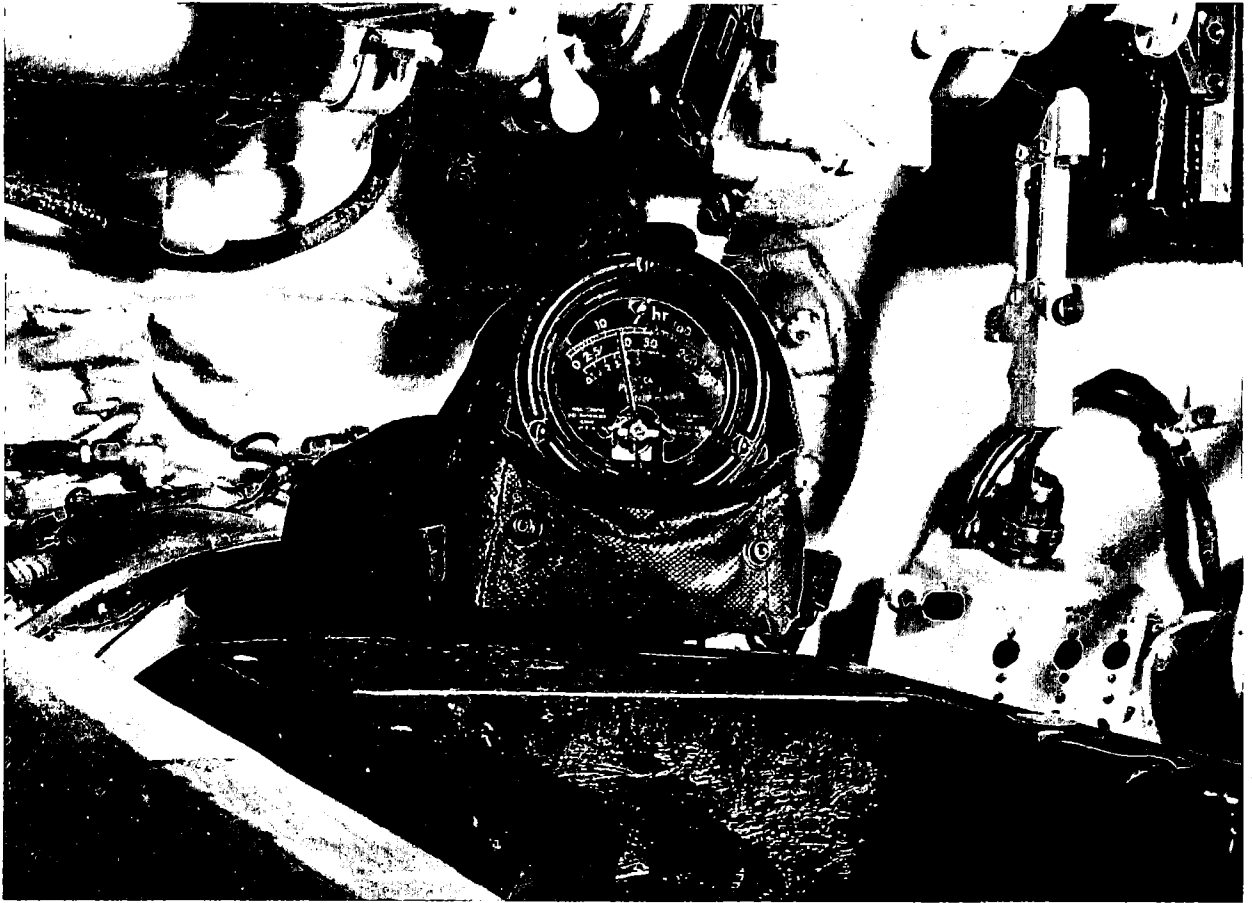


Figure 13. Survey meter location (tank).

porting is accomplished, using communication methods in the preference order indicated below:

- (1) The survey party reports by radio direct to the control party of the authority directing the survey. Radio communication provides more timely data and more flexible control than other methods of communication.
- (2) The survey party reports by radio to the nearest area communications center and thence to the control party of the authority directing the survey.
- (3) The survey party proceeds to the nearest unit and uses its facilities to report through the area communications center to the authority directing the survey.
- (4) The survey party proceeds to the

nearest area communications center and reports by available means direct to the control party of the authority directing the survey.

- (5) The survey party physically delivers data to the control party of the authority directing the survey.

c. Guidance. More precise information on reporting and recording survey data is provided in the unit SOP or is established at the survey party briefing.

d. Security. Ground radiological survey information is of intelligence value to the enemy. Proper security procedures for the reporting of these data (particularly unit designations and locations) are established by the unit SOP. The more detailed the briefing of the survey parties, the more easily security can be maintained.

72. Capability of Ground Survey Parties

Any powered vehicle is satisfactory for conducting ground surveys. All vehicles have approximately the same area coverage capability of between 15 and 40 square kilometers per hour per vehicle, depending upon the de-

gree of detail required, the road net, and trafficability of the contaminated area. However, because of the superior shielding and cross-country characteristics of the tracked armored vehicle, this type of vehicle is preferred.

Section IV. PERSONNEL AND EQUIPMENT REQUIREMENTS

73. General

Personnel and equipment for ground survey parties and monitors for aerial survey parties are drawn from the company/battery CBR teams subordinate to the authority directing the survey. Reconnaissance units have the capability (if provided aircraft) of performing aerial or ground surveys as a priority mission when required.

74. Personnel Requirements

a. Ground Survey Parties. The number of survey parties required at any one time will depend upon the tactical and administrative support situation, the terrain, time available, detail desired, and other factors.

b. Aerial Survey Parties. The same factors which influence the number of survey parties required for ground surveys are considered in selecting the number of parties required for aerial surveys. *Monitors for the aerial survey parties should be selected from units normally located near an aircraft landing area to reduce the time in getting the survey parties briefed and airborne.* Primary sources for monitors are—

- (1) Aerial observers who habitually fly reconnaissance and surveillance missions.
- (2) Reconnaissance and armored cavalry-type units.

c. Control Parties. Control parties established at brigade or battalion level utilize organic personnel. At other headquarters, the control party must be organized within established TOE's if it is not provided as an augmentation.

d. Training. The training of monitors (par. 35) is applicable to training of survey parties. In addition, survey parties and control parties must receive thorough training in survey tech-

niques and procedures in order to be effective as a team. This training cannot consist merely of instruction but must include frequent practice surveys in field exercises, CPX's, and Army training tests. Practice by survey party personnel reduces the time required to obtain and report survey data; practice by control party personnel reduces the time required to process and disseminate the data.

75. Equipment Requirements for Survey Parties

a. Instrument for Measuring Dose Rates. The radiacmeter IM-174/PD (Standard A) will be used for measuring dose rates.

b. Instruments for Measuring Dose. The dosimeter IM-93 will be used for measuring dose. The dosimeter IM-147 may also be used when available because its range of 0 to 50 rad allows more accurate measurement of low doses.

c. Radiological Data Sheet. DA Form 1971-1-R (Radiological Data Sheet Route Technique or Course Leg Technique), will be needed for recording information collected during the survey. DA Form 1971-1-R (Radiological Data Sheet Route Technique or Course Leg Technique (Ground and Aerial Survey)) will be locally reproduced on 8" x 10½" paper.

d. Watch. A watch will be required to determine the time at which survey readings are taken. For aerial survey, a stopwatch or a watch with a sweep-second hand is required to time the interval between readings.

e. Transportation. Vehicles with high radiation shielding characteristics should be used for ground surveys. Aircraft should be selected in accordance with the preference order criteria of table 4.10 for aerial surveys.

f. Communications. Communications equipment necessary for accomplishing the reporting procedures specified in paragraph 71 is required.

CHAPTER 5

TRANSMISSION OF FALLOUT CONTAMINATION PLOT

76. General

Operations in a nuclear environment will require frequent exchange of fallout contamination information. Since duplication facilities and distribution means are limited in the field, transmission and exchange of fallout contamination plots must be accomplished by use of existing communications facilities.

a. Fallout Contamination Overlay. When rapid distribution means are available, the fallout contamination overlay should be used if time permits preparation and duplication. This overlay will give the recipient a detailed, accurate picture of the fallout contamination situation for a particular area of interest.

b. Fallout Contamination Plot Message. When time and distribution means do not permit use of the fallout contamination overlay, fallout contamination plots of areas of immediate operational interest may be rapidly prepared and transmitted by existing communications facilities, using the format of the fallout contamination plot message.

77. Fallout Contamination Plot Message

a. Preparation for Transmission. Fallout contamination plots are prepared by the CBRE, based upon monitoring and survey data received through normal intelligence collection efforts. The CBRE will prepare the fallout contamination plot message for transmission using the plotter, format, and procedures described below.

b. Fallout Contamination Plotter. The fallout contamination plotter will be the basis for the transmission and receipt of fallout contamination information. The plotter is composed of concentric circles at 1-kilometer intervals on a map scale of 1:50,000 and radial lines

at 10° intervals (fig. 14). The plotter may be adapted for use with any map scale by assigning appropriate values for each concentric interval; for example, 2 kilometers for 1:100,000 or 5 kilometers for 1:250,000.

c. Format for Fallout Contamination Plot Message. The data necessary for plotting the fallout contamination plot will be transmitted in the format shown below, preceded by the phrase, "Fallout Contamination Plot Message."

Fallout Contamination Plot Message

ZULU	DDtttt
ALFA	yyzzzzzz
BRAVO	rrrr rrrr rrrr
CHARLIE	bbb cde cde cde
through LIMA	
MIKE	bbb cde rrrr
through XRAY	
YANKEE	rrrr bbbcde bbbcde

d. The significance of of each line is as indicated below:

- (1) ZULU DDtttt—This line is the date-time group of the burst with DD the day and tttt H-hour in Greenwich Civil Time (GCT).
 - (2) ALFA yyzzzzzz—This line provides the coordinates of ground zero with yy the two letters representing the appropriate 100,000-meter grid reference box and zzzzzz the coordinates of ground zero within this grid reference box.
 - (3) BRAVO rrrr rrrr rrrr—This line provides the normalized $(H + 1)$ dose-rate contours, rrrr, to be plotted, in groups of 4 digits for each contour.
 - (4) CHARLIE through LIMA bbb cde cde cde—These lines provide data for plotting the dose-rate contours indicated in the line BRAVO.
- (a) The first 3 digits in each line trans-

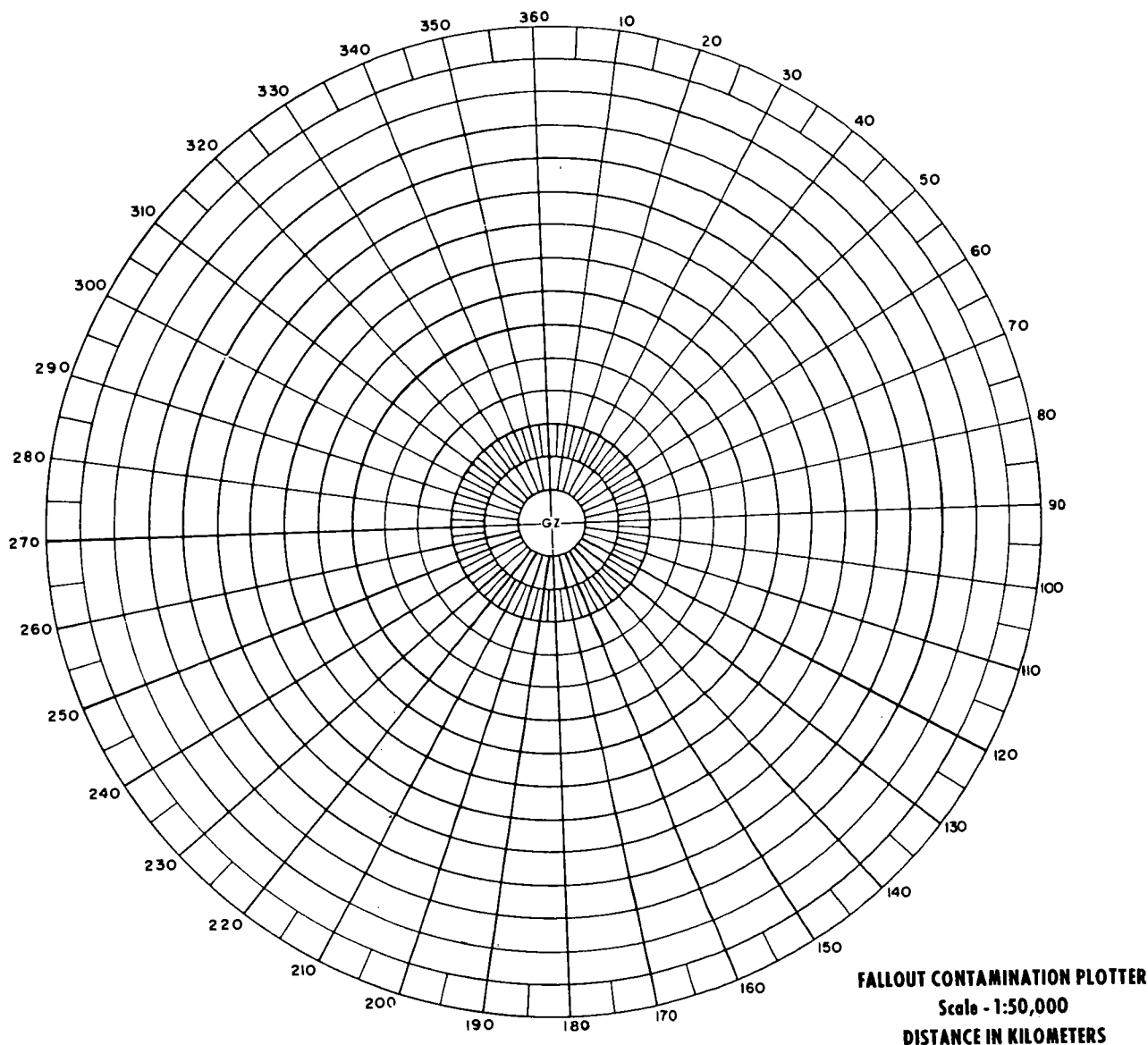


Figure 14. Fallout contamination plotter.

mitted provide the azimuth, bbb, in degrees from grid north of a radial line from ground zero.

- (b) The second 3 digits, cde, provide the distance in kilometers, cd, and tenths of kilometers, e, from ground zero along the radial line for the highest dose-rate contour from line BRAVO.
- (c) Each succeeding set of 3 digits, cde,

provides the distance in kilometers, cd, and tenths of kilometers, e, from ground zero along the radial line for the next lower dose-rate contour from line BRAVO.

- (5) MIKE through XRAY bbb cde rrrr—These lines provide data for plotting hot spots, given in 10-digit groups.
- (a) The first 3 digits in each line transmitted provide the azimuth, bbb, in

degrees from grid north of a radial line from ground zero.

- (b) The second 3 digits, cde, provide the distance in kilometers, cd, and tenths of kilometers, e, from ground zero along the radial line to the hot spot.
- (c) The last 4 digits provide the normalized $(H + 1)$ dose rate, rrrr, of interest.
- (6) YANKEE rrrr bbbcd bbbcd—If the contamination pattern has a hooked end, this line provides additional data necessary for plotting a hooked end contour. If the pattern has more than one hooked end contour, BREAK is transmitted between the data describing each contour.
- (a) The first 4 digits provide the dose rate, rrrr, of the hooked end.
- (b) Each succeeding set of 6 digits, bbbcd, represents the azimuth and distance for a point of interest, with the first 3 digits providing the azimuth, bbb, in degrees from grid north of a radial line from ground zero and the second 3 digits, cde, providing the distance in kilometers, cd, and tenths of kilometers, e, from ground zero along the radial line.

e. Sample Fallout Contamination Plot Message. The sample fallout contamination plot message which follows was prepared in accordance with the format and information of c and d above.

Sample Fallout Contamination Plot Message

ZULU	250915
ALFA	ET059120
BRAVO	0150 0050 0010
CHARLIE	360 010 020 050
DELTA	060 050 080 310
ECHO	070 070 130 290
FOXTROT	090 040 080 200
GOLF	110 020 050 100
HOTEL	170 010 020 040
INDIA	250 010 020 030
MIKE	072 190 0050
NOVEMBER	075 210 0050
OSCAR	078 190 0050
PAPA	075 170 0050
YANKEE	0010 060260 062200 END

78. Plotting Data from Fallout Contamination Plot Message

a. General. In plotting a contamination plot from a fallout contamination plot message, the fallout contamination plotter should be used by the recipient to facilitate plotting of the data. The plotter may be reproduced locally for field use.

b. Step-by-Step Procedure.

- (1) *Step 1.* Identify the date and time of burst on the plotter, using the information from line ZULU.
- (2) *Step 2.* Identify ground zero on the plotter using the information from line ALFA.
- (3) *Step 3.* Prepare a worksheet from the data provided in the remaining lines of the message. The worksheet will show dose-rate contours to be plotted, dose rates of interest (hot spots, hooked end), azimuths, and distances from ground zero.
- (4) *Step 4.* Plot the points of the dose-rate contours on the plotter, following along the azimuths to the distances and contours indicated in the worksheet ((3) above).
- (5) *Step 5.* Plot the points representing any hot spots from lines MIKE through XRAY, using the worksheet.
- (6) *Step 6.* Plot the points representing hooked ends from line YANKEE, using the worksheet.
- (7) *Step 7.* Connect the points representing equal dose-rate contours with a smooth curve.
- (8) *Step 8.* Orient the plotter on the situation map, using the information derived in (2) above. Orient the plotter with the center at ground zero and the 360° radial line parallel to grid north.

Note. After the plotter has been oriented on the situation map, the portion of the fallout contamination plot which was too far downwind to be plotted on the plotter can be added.

c. Example Problem. Using the sample fallout contamination plot message from paragraph 77e and the step-by-step procedure of b

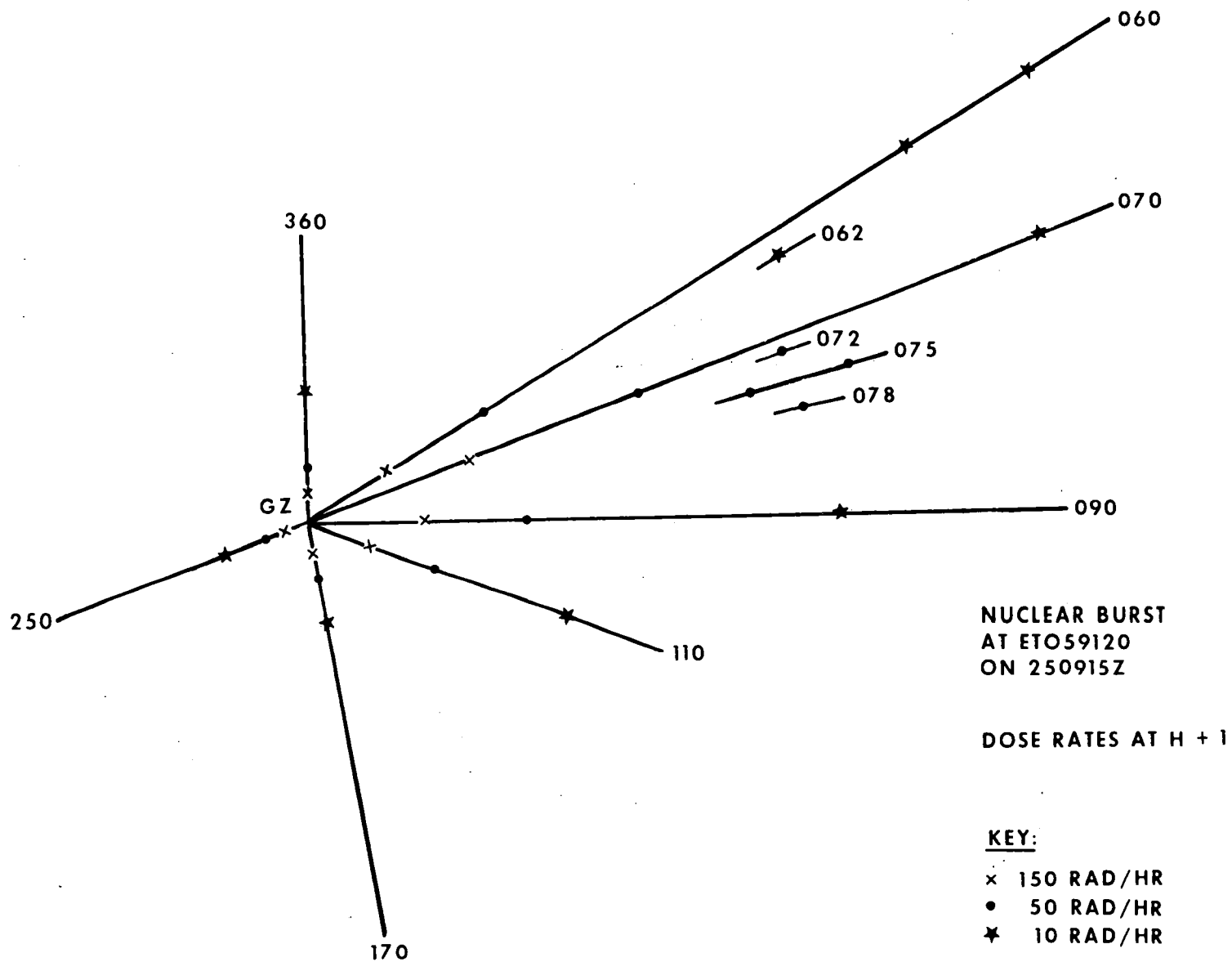
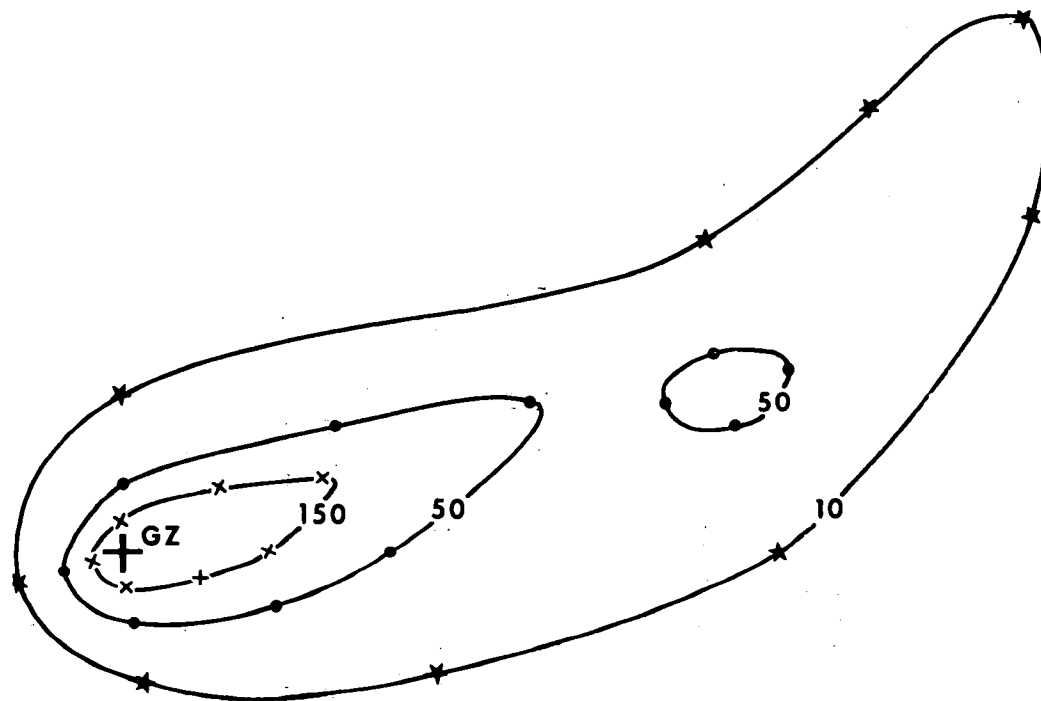


Figure 15. Example problem, fallout contamination plot.



NUCLEAR BURST
AT ETO59120
ON 250915Z

DOSE RATES AT H + 1

KEY:

- x 150 RAD/HR
- 50 RAD/HR
- ★ 10 RAD/HR

Figure 15—Continued.

above, plot the fallout contamination plot. Insert the appropriate information on the fallout contamination plotter with a grease pencil. Figure 15 illustrates the example problem.

- (1) *Step 1.* The time of burst from the message is 0915 hours and the day of the month is the 25th.
- (2) *Step 2.* The coordinates of ground zero are ET059120.
- (3) *Step 3.* Prepare the worksheet from the sample fallout contamination plot message, showing dose-rate contours,

dose rates for hot spots and hooked ends, azimuths, and distances from ground zero, as given in table III. The dose-rate contours from line BRAVO are 150 rad/hr, 50 rad/hr, and 10 rad/hr; the dose rate for hot spots from lines MIKE through PAPA is 50 rad/hr; and the hooked end dose rate from line YANKEE is 10 rad/hr. The azimuths and the distances from ground zero are derived from the appropriate lines of the message. Use this worksheet to complete the plot.

Table III. Sample Fallout Contamination Plot Message

Line	Azimuth (degrees)	Distance from ground zero (kilometers)		
		150 rad/hr	50 rad/hr	10 rad/hr
BRAVO (dose-rate contours)				
CHARLIE-----	360	1	2	5
DELTA-----	60	5	8	31
ECHO-----	70	7	13	29
FOXTROT-----	90	4	8	20
GOLF-----	110	2	5	10
HOTEL-----	170	1	2	4
INDIA-----	250	1	2	3
MIKE-PAPA (hot spot dose rates)				
MIKE-----	72	-----	19	
NOVEMBER-----	75	-----	21	
OSCAR-----	78	-----	19	
PAPA-----	75	-----	17	
YANKEE (hooked end dose rates)				
	60	-----	-----	26
	62	-----	-----	20

- (4) *Step 4.* Plot the points for the dose-rate contours on the plotter (b(4) above).
- (5) *Step 5.* Plot the points for the hot spots on the plotter (b(5) above).
- (6) *Step 6.* Plot the points for the hooked end on the plotter (b(6) above).
- (7) *Step 7.* Connect the points represent-

ing the equal dose-rate contours with a smooth curve (b(7) above).

Note. DO NOT join the contour for the hot spots with the main contours for the same dose rate.

- (8) *Step 8.* Orient the completed plot on the situation map as described in b(8) above. The completed plot is shown in figure 15.

CHAPTER 6

OPERATIONAL ASPECTS OF RESIDUAL RADIATION

Section I. FALLOUT

79. General

a. Influence on Operations. Fallout can have a major influence on tactical operations because—

- (1) It can produce casualties over very large areas *outside* the kill area from initial effects. It is potentially the most important casualty-producing effect of a nuclear weapon.
- (2) It can (outside the casualty area, from initial effects) restrict vast areas to unprotected troops.
- (3) It can increase the logistical problems of affected units. It can limit the unrestricted use of streets, roads, and other communication lines for critical periods. Tremendous engineer and other service efforts are required to decontaminate fallout areas.
- (4) It can destroy personnel while leaving intact installations and materiel which can be used at a later date.

b. Surface Burst. The surface burst, mainly because of the fallout it produces, is potentially the most effective type of burst. Depending on the yield (W) of the weapon, the surface burst can produce many times the number of casualties produced by other type bursts.

c. Forecast of Effects. It is necessary, therefore, for commanders to have a means of predicting, in advance of exposure, the anticipated total dose of radiation to be received by personnel who will occupy or pass through a fallout area.

80. Decay Calculations

a. General. Fallout consists mainly, but not entirely, of fission products produced by the nuclear explosion. The fission products consti-

tute a very complex mixture of over 200 different forms (isotopes) of 36 elements. Most of these isotopes are radioactive, decaying by the emission of beta particles frequently accompanied by gamma radiation. The spontaneous emission of beta particles, alpha particles, and gamma rays is called radioactive decay.

b. Rate of Decay. The rate of decay must be known to perform dose-rate or dose calculations. The rate at which contamination decays is the decay constant (n). The decay constant indicates the rate at which the dose rates will decrease with time. When the decay constant is not known, a decay constant of 1.2 has been established as standard.

c. Decay Nomogram. The decrease in the radiation dose rate can be calculated by the use of a nomogram. The residual radiation decay (fallout) nomogram, figure 16, allows the user to find the dose rate at any time if a dose rate at a known time after the burst is available. This nomogram contains 4 lines of 2 scales each which denote time after burst (in hours) for nonstandard decay constants as indicated above each scale and 1 line (the index scale) which denotes time after burst (in hours) for the standard rate ($n=1.2$) of decay. The R_1 scale, at the right of the time scales, shows dose rates at $H + 1$; the R_2 scale, at the left of the time scales, shows dose rates at times other than $H + 1$. The outside left and right lines are reference lines to be used in alining the hairline. Use of the decay nomogram, involving standard decay (1.2), is shown in the examples below. For use involving decay constants other than standard, see paragraphs 86 and 87.

d. Example Problems. In working with nomograms, care should be taken to be as consistent as possible when joining values with

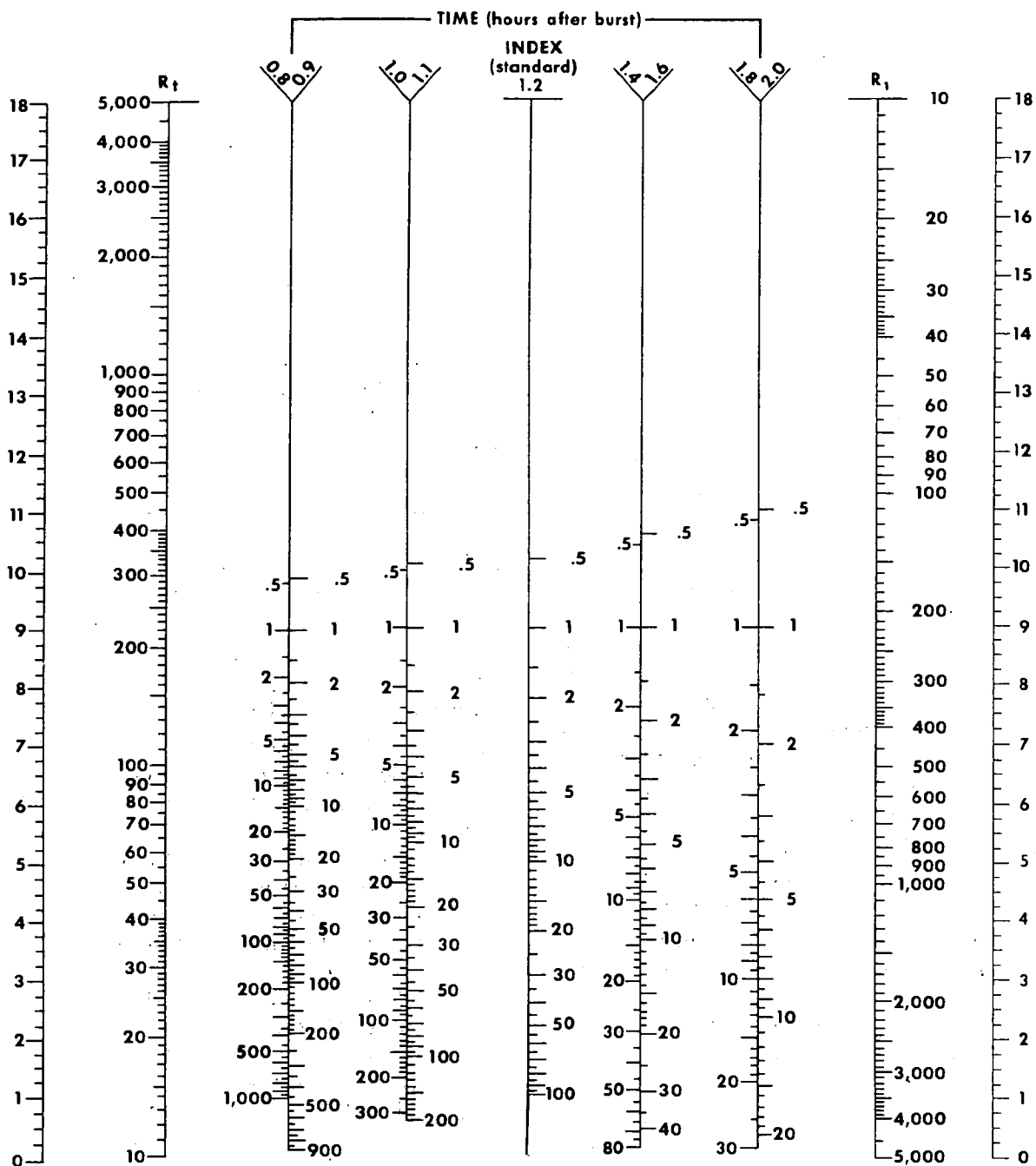


Figure 16. Residual radiation decay (fallout).

the hairline. Be sure that the hairline intersects the vertical line and the interpolated value (tickmark) as closely as possible. Dose-rate values smaller or greater than those shown on the nomogram in figure 16 may be reported. In the case of *smaller* values; *multiply*

the dose rate by 10 and proceed with the calculation as shown in example problem 4. In the case of *greater* values, *divide* the dose rate by 10, proceed with the calculation, and multiply the resulting dose rate by 10. When using this process, *NEVER* multiply or divide a number

from the time scale; multiply or divide, as appropriate, using only the dose-rate values.

(1) *Example problem 1.*

GIVEN. $R_i = 200$ rad/hr at $H + 5$ hours.

FIND. R_i .

ANSWER. 1,350 rad/hr.

SOLUTION. Aline the hairline with the 5-hour tickmark of the 1.2 (index) scale and equal values of the left and right reference lines. Pivot the hairline about its point of intersection ($H + 5$) with the index scale to the 200 rad/hr point on the R_i scale. Read the dose rate at $H + 1$ as 1,350 rad/hr at the point of intersection of the hairline with the R_i scale.

(2) *Example problem 2.*

GIVEN. $R_i = 1,000$ rad/hr.

FIND. R_i at $H + 6$ hours.

ANSWER. 120 rad/hr.

SOLUTION. Aline the hairline with the 6-hour tickmark of the index scale and equal values of the reference lines. Pivot about the point of intersection ($H + 6$) to the 1,000 rad/hr point on the R_i scale. Read R_i as 120 rad/hr at the point of intersection of the hairline with the R_i scale.

(3) *Example problem 3.*

GIVEN. $R_i = 1,000$ rad/hr.

FIND. Time when $R_i = 700$ rad/hr.

ANSWER. $H + 1.3$ hours.

SOLUTION. Connect 1,000 rad/hr on the R_i scale and 700 rad/hr on the R_i scale with the hairline. Read time as $H + 1.3$ hours at the point of intersection of the hairline and the index scale.

(4) *Example problem 4.*

GIVEN. $R_i = 200$ rad/hr.

FIND. R_i at $H + 25$ hours.

ANSWER. 4.4 rad/hr.

SOLUTION. Connect 2,000 rad/hr (10×200 rad/hr) on the R_i scale and 25 on the index (time) scale

with the hairline. Read R_i as 4.4 rad/hr on the R_i scale. Divide this dose rate by 10 since the R_i value was multiplied by 10; then, the dose rate at $H + 25$ hours is 4.4 rad/hr.

81. Total Dose Predictions

a. *General.* The dose rate of radiation does not directly determine whether or not personnel become casualties. Casualties are dependent on total dose received. If the dose rate were constant, total dose would simply be the product of dose rate and time in the contaminated area, just as in a road-movement problem rate $\times$ time = distance. But the dose rate is continually diminishing because of decay; hence, the calculation is a little more complicated. The predicted dose is always less than the product of dose rate at time of entry and duration of stay except as indicated in *c* below.

b. *Total Dose Calculations.* The nomogram in figure 17 is used for predicting total dose to be received while operating in a fallout radiation area. This nomogram relates total dose, dose rate referenced to one hour after the burst, stay time, and entry time. The index scale is a pivoting line which is used as an intermediate step between D and R_i and T_s and T_e . The four values on this nomogram are defined as follows:

D = total dose in rad.

R_i = dose rate one hour after burst ($H + 1$). When using this nomogram, a dose rate referenced to one hour after the burst ($H + 1$) must ALWAYS be used; NEVER use a dose rate taken at any other time. See *c* below.

T_s = stay time in hours.

T_e = entry time (hours after burst).

Any 1 of these values may be determined from the nomogram if the other 3 values are known, as shown in examples of *d* below.

c. *Essential Information.*

(1) If the available dose rate was taken at a time other than $H + 1$ hour, the value of R_i may be found by using the residual radiation decay (fallout) nomogram (fig. 16) and the procedures of paragraph 80.

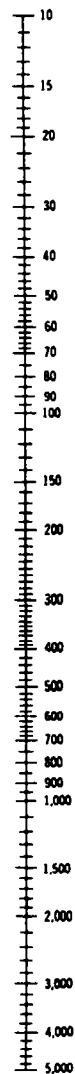
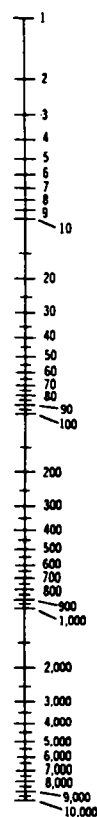
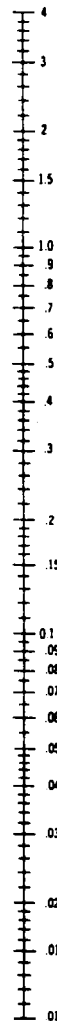
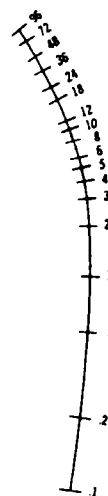
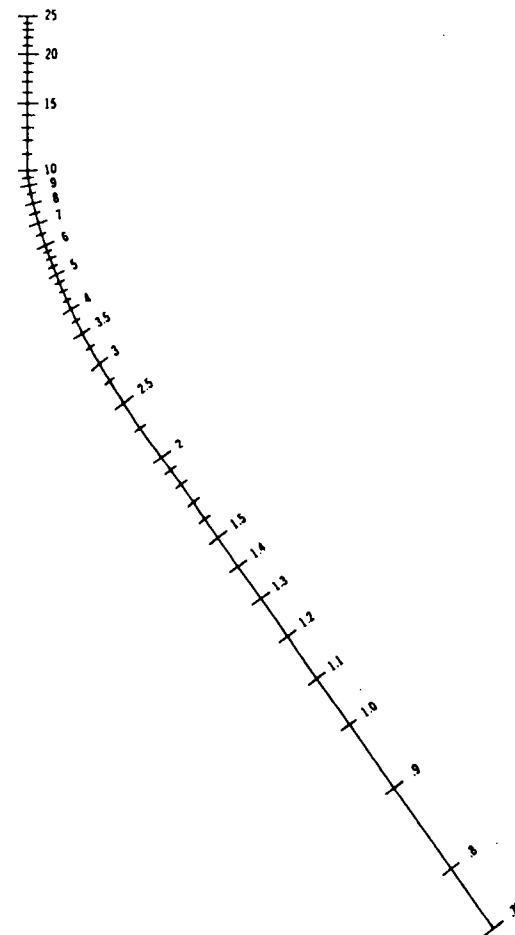
TOTAL DOSE**(D)****DOSE RATE****(R₁)****INDEX****STAY TIME (T_S)**
(hours)**ENTRY TIME (T_e)**
(hours after burst)

Figure 17. Total dose (fallout).

- (2) In applying the given values, D and R_1 are used together and T_e and T_s are used together. When working with the total dose nomogram, always start the problem on the side of the nomogram for which two values are known. If D and R_1 are given, start with these two known values; if T_e and T_s are given, start with them. Never begin a problem by joining D or R_1 with either of the time values.

d. Example Problems.

(1) *Example problem 1.*

GIVEN. $R_1 = 200$ rad/hr.
 $T_e = H + 1.5$ hours.
 $T_s = 1$ hour.

FIND. D .

ANSWER. 86 rad.

SOLUTION. On figure 17, connect $H + 1.5$ hours on the T_e scale and 1 hour on the T_s scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 200 rad/hr on the dose rate (R_1) scale. Read $D = 86$ rad on the total dose (D) scale.

(2) *Example problem 2.*

GIVEN. $D = 20$ rad.
 $R_1 = 100$ rad/hr.
 $T_s = 1$ hour.

FIND. T_e .

ANSWER. $H + 3.4$ hours.

SOLUTION. On figure 17, connect 20 rad on the D scale and 100 rad/hr on the R_1 scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 1 hour on the T_s scale. Read $T_e = 3.4$ hours on the T_e scale.

e. Calculations When Time of Entry is After $H + 24$ Hours. By 24 hours after burst, the change in the rate of decay is so low that it is relatively insignificant. Therefore, in making estimates of the total dose to be received when entry into the contaminated area is later than $H + 24$ hours, the total dose is obtained by multiplying the dose rate at entry time by the stay time.

Symbolically, this is written:

$$D = R_{Te} \times T_s, \text{ where:}$$

D = total dose.

R_{Te} = dose rate at time of entry.

T_s = time of stay.

82. Validity

The calculations above and the nomograms in figures 16 and 17 are valid only if the dose-rate reading is made after the radioactive particles have ceased falling. For example, a dose-rate reading made one hour after the burst while fallout is still arriving is not valid for determining what the dose rate will be at a later time since there is no way to determine how much more fallout will arrive.

83. Transmission Factor

a. General. A transmission factor (TF) is used to determine the reduction in the dose received when personnel are protected (shielded) from radiation (par. 14). Transmission factors have been established for certain shielding environments and are given in figure 18. These transmission factors may be used in determinations of shielded dose rate or total dose.

b. Examples.

- (1) In example problem 1 (par. 81d(1)), the outside dose (OD) as calculated from the nomogram was 86 rad. The inside dose (ID) is calculated by use of a transmission factor. What dose would troops in armored carriers receive? The TF for an armored carrier is 0.6 (fig. 18).

$$\begin{aligned} ID &= OD \times TF \\ &= 86 \times 0.6 \\ &= 51.6 \text{ rad.} \end{aligned}$$

- (2) Transmission factors may also be applied to dose rates. A measured outside dose rate (OD) is 100 rad/hr. The inside dose rate (ID) is calculated by use of the transmission factor. Find the dose rate inside an armored carrier.

$$\begin{aligned} ID &= OD \times TF \\ &= 100 \times 0.6 \\ &= 60 \text{ rad/hr.} \end{aligned}$$

Environment shielding	Transmission factor	Correlation factor
VEHICLES		
<u>Armored</u>		
Carrier	0.6	1.67
Tanks		
Light	0.2	5
Medium or heavy	0.1	10
<u>Trucks</u>		
¼-ton	0.8	1.25
¾-ton	0.7	1.44
2½-ton	0.6	1.67
4-ton to 7-ton	0.5	2
STRUCTURES		
<u>Multistory buildings</u>		
Top floor	0.01	100
Intermediate floor	0.02	50
Lower floor	0.1	10
Basement	0.05	20
<u>Frame house</u>		
First floor	0.5	2
Basement	0.1	10
URBAN AREA (In open)	0.7	1.4
WOODS	0.8	1.25
SHELTER, CLOSED	0.005	200
(3-foot earth cover)		
FOXHOLES	0.1	10

Figure 18. Transmission/correlation factors for residual radiation.

84. Crossing a Fallout Area

a. General. It may be necessary to cross an area in which there is residual radiation. Such an occasion might arise in exploitation of our own surface bursts or in retrograde or offensive operations coupled with enemy-delivered surface bursts. In nuclear warfare it is possible that extensive areas will be made residually radioactive. These areas will be habitable eventually, but operations in such areas will be complicated because of the necessity for keeping to a minimum the total dose which will be received by our troops.

b. Commander's Questions. The problem of crossing a contaminated area, from a command point of view, is essentially "what total dose will be received?" In general, the primary objective is to keep the total dose to a minimum. This may be done by keeping the stay time as short as possible, by delaying the entry time as long as possible, and by providing shielding. The selection of one, or any combination, of these three actions is dependent upon the operational situation at the time. The objective of keeping the total dose to a minimum influences route selection. The shortest route, or the route that can be traversed most quickly, provides the minimum stay time. If possible, routes through areas of lowest dose rates should be selected. The use of tanks, armored vehicles, or sandbags on the floors of cargo trucks will provide shielding and reduce the total dose received by personnel.

c. Average Dose Rate. In analyzing the problem of crossing a contaminated area, it is evident that the dose rate will increase as the center of the area is approached then will decrease beyond the center of the area and as the far side is approached. When individuals or units are required to cross a contaminated area, it is necessary to determine an average dose rate to be used in predictions of total dose. The average dose rate represents a mean value to which the individual is exposed during the time of stay. A reasonable approximation of the average dose rate (R_{avg}) in crossing a fallout area can be obtained by dividing the maximum dose rate (R_{max}) encountered, or expected to be encountered, by two. Symbolically, this is written as $R_{avg} = \frac{R_{max}}{2}$.

d. Procedures. After the average dose rate has been determined, entry times can be computed, based on calculated stay times, which will keep the total dose below a specified maximum; or total doses can be computed for specified entry times and stay times. These calculations are made in the manner described below.

e. Calculations.

(1) In calculating the total dose to be received in crossing a fallout area, it is necessary to know the time of entry into the area, the average dose rate along the route, and the time of stay within the area inclosed by the 10 rad/hr at $H + 1$ contour line. Use the total dose (fallout) nomogram in figure 17 and the methods of paragraph 81 for these calculations.

(2) In a crossing the average dose rate is equal to one-half the maximum dose rate encountered on the route (*c* above). If the maximum dose rate encountered is 60 rad/hr, then,

$$\begin{aligned} R_{avg} &= \frac{1}{2} R_{max} \\ &= \frac{1}{2} \times 60 \text{ rad/hr} \\ &= 30 \text{ rad/hr.} \end{aligned}$$

(3) In using figure 17, the average dose rate must be normalized (taken back) to $H + 1$. Refer to paragraph 80*c* and *d* for determining dose rate at $H + 1$ by using figure 16.

(4) In calculating the total dose to be received when crossing a fallout area, follow the stepwise procedure outlined below.

(a) Calculate the average dose rate.

$$R_{avg} = \frac{1}{2} R_{max}$$

(b) Normalize R_{avg} to $H + 1$, unless the dose-rate data have already been referenced to $H + 1$.

(c) Calculate the time required to cross the fallout area inclosed by the 10 rad/hr ($H + 1$) contour line.

$$T_s = \frac{\text{distance}}{\text{speed}}$$

(d) Find the outside dose, using figure 17.

(e) Calculate the inside dose, if shielding is involved; obtain TF from figure 18.

$$ID = OD \times TF.$$

f. Example Problems.

(1) Example problem 1.

GIVEN. Troops are to cross the fallout area shown in figure 19 at H + 1 in armored carriers at a rate of speed of 10 kilometers per hour (km/hr). The route from A to B, a distance of 5 kilometers (km), will be used.

FIND. Total dose which will be received by troops.

ANSWER. 34.2 rad.

SOLUTION.

(a) Calculate the average dose rate.

$$\begin{aligned} R_{avg} &= \frac{1}{2} R_{max} \\ &= \frac{1}{2} (300 \text{ rad/hr}) \\ &= 150 \text{ rad/hr (at H + 1).} \end{aligned}$$

(b) Normalize R_{avg} to H + 1. R_{avg} is already at H + 1.

(c) Calculate time of stay.

$$\begin{aligned} T_s &= \frac{\text{distance}}{\text{speed}} \\ &= \frac{5 \text{ km}}{10 \text{ km/hr}} \\ &= 0.5 \text{ hour.} \end{aligned}$$

(d) Find the outside dose, using figure 17.

$$\begin{aligned} R_{avg} &= 150 \text{ rad/hr.} \\ T_e &= H + 1 \text{ hour.} \\ T_s &= 0.5 \text{ hour.} \\ D &= 57 \text{ rad.} \end{aligned}$$

(e) Calculate the inside dose.

$$TF = 0.6 \text{ (fig. 18).}$$

$$\begin{aligned} ID &= OD \times TF \\ &= 57 \times 0.6 \\ &= 34.2 \text{ rad.} \end{aligned}$$

(2) Example problem 2.

GIVEN. Troops are to cross the fallout area shown in figure 20 at H + 2 in 2½-ton trucks moving at 15 km/hr, using the route A-B-C-D-E. Total distance = 4.5 km.

FIND. Total dose which will be received by troops.

ANSWER. 7.2 rad.

SOLUTION.

(a) Calculate average dose rate.

$$\begin{aligned} R_{avg} &= \frac{1}{2} R_{max} \\ &= \frac{1}{2} (200 \text{ rad/hr}) \\ &= 100 \text{ rad/hr (at H + 1).} \end{aligned}$$

(b) Normalize R_{avg} to H + 1. R_{avg} is already at H + 1.

(c) Calculate time of stay.

$$\begin{aligned} T_s &= \frac{\text{distance}}{\text{speed}} \\ &= \frac{4.5 \text{ km}}{15 \text{ km/hr}} \\ &= 0.3 \text{ hour.} \end{aligned}$$

(d) Find the outside dose, using figure 17.

$$\begin{aligned} R_{avg} &= 100 \text{ rad/hr.} \\ T_e &= H + 2 \\ T_s &= 0.3 \text{ hour} \\ D &= 12 \text{ rad.} \end{aligned}$$

(e) Calculate the inside dose.

$$TF = 0.6 \text{ (fig. 18).}$$

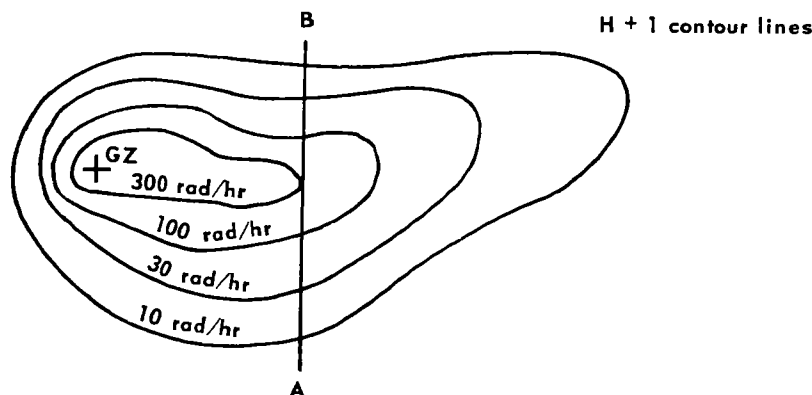
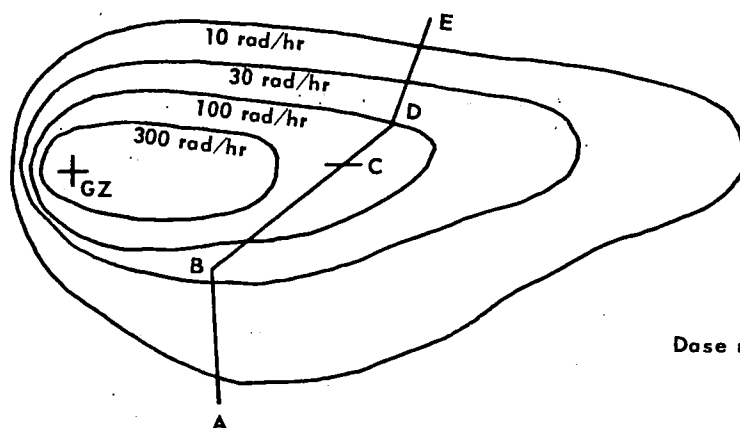


Figure 19. Crossing a fallout area, example problem 1.



Dose rates at H + 1

Figure 20. Crossing a fallout area, example problem 2.

$$\begin{aligned}
 ID &= OD \times TF \\
 &= 12 \times 0.6 \\
 &= 7.2 \text{ rad.}
 \end{aligned}$$

85. Radiac Calculator

a. General. The M1 radiac calculator, a component part of the M28 Nuclear Calculator Set, is designed to provide the field commander with a rapid means of performing calculations similar to those described in this section when the decay constant is standard ($n=1.2$).

b. Description. The M1 radiac calculator (fig. 21) consists of three opaque, white laminated plastic discs. An inner disc (1) and an intermediate disc (2) are mounted concentrically on a fixed outer disc (3) by means of an aluminum rivet which permits the inner and intermediate discs to rotate freely on the fixed outer disc. The calculator is issued in a green plastic protective envelope.

- (1) *Inner disc.* The inner disc is $1\frac{5}{16}$ inches in diameter and contains an ENTRY-EXIT TIME AFTER BURST logarithmic scale (scale C), divided into minutes, hours, days, and weeks to infinity. The scale is imprinted on the outer edge of the disc.
- (2) *Intermediate disc.* The intermediate disc is $3\frac{7}{8}$ inches in diameter and contains a logarithmic scale (scale B), divided into minutes, hours, days, and weeks, imprinted on its outer

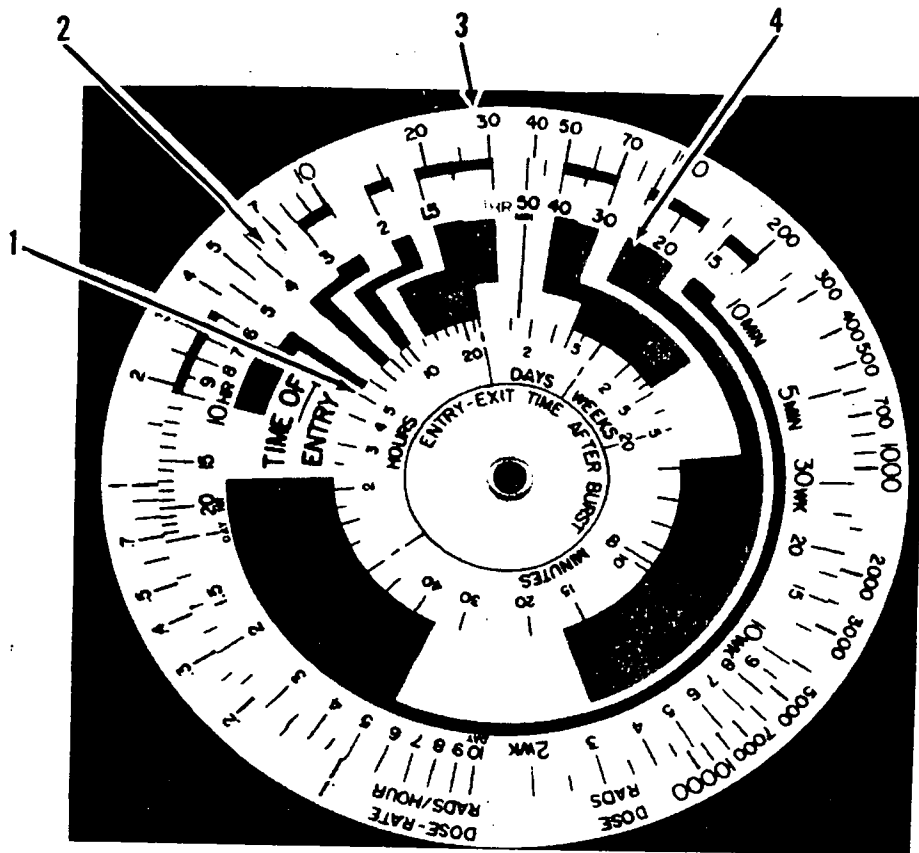
edge. A TIME OF ENTRY index line is imprinted on the intermediate disc and is used as an alignment index for scale C on the inner disc. Alternate red and black bands printed on the intermediate disc form a set of irregular red, white, and black guide bands from scale C to scale B.

- (3) *Outer disc.* The outer disc is $4\frac{1}{2}$ inches in diameter and has a dual purpose logarithmic scale (scale A), divided into a DOSE RAD scale and a DOSE RATE RAD/HOUR scale, imprinted on its outer edge.
- (4) *Instructions.* The back of the M1 calculator contains brief instructions on the use of the calculator and a table of transmission factors for several shielding environments.

Note. The transmission factors on the back of the calculator do not agree with those published in this manual. The transmission factors from figure 18 should be used, if possible.

c. Use. Problems involving decay, normalizing, dose, dose rate, time of stay, and time of exit can be solved with the M1 calculator. For example problems, see TB CML 85. In the descriptions that follow, note that the procedures are reversible.

- (1) *Decay calculations.* This type of calculation is accomplished by using scales A and B. Scale A is the dose



1. Inner disc (scale C)
2. Intermediate disc (scale B)
3. Outer disc (scale A)
4. Guide band

Figure 21. M1 radiac calculator.

rate and scale B is the time. Locate the known dose rate or predicted dose rate on scale A and rotate scale B until the corresponding time is aligned with the dose rate. The guide is now properly aligned to show dose rates at any time by simply reading the time scale (scale B) and the corresponding dose rate (scale A).

- (2) *Total dose calculations.* This calculation is performed as follows: Aline the dose rate (scale A) with the corresponding time (scale B); hold this alinement and locate the time of entry

on scale C; aline time of entry (scale C) with index; locate time of exit (time of stay added to time of entry) on scale C and note the red, white, and black guide bands; follow the appropriate guide band to scale A and read the corresponding value on scale A. This gives the total dose with no transmission factor applied. To correct for a shielding environment, use appropriate transmission factor from figure 18 or use a transmission factor from the back of the calculator for an approximation.

Section II. NONSTANDARD DECAY OF FALLOUT

86. General

a. *Explanation.* To define nonstandard decay we must first define standard decay. The calculations in paragraphs 79 through 85 are based on an equation for a standard decay constant of 1.2 which is $R_t = R_1 t^{-1.2}$. We may now define standard decay by stating that decay is standard when the actual dose rates from fallout do not differ significantly from those predicted by this equation. Decay is nonstandard when the actual dose rates from fallout *do* differ significantly from those predicted by the above equation.

b. *Factors Affecting Decay Rate.* The factors that affect the rate of decay of fallout may be divided into several broad groups as follows:

- (1) The type of weapon and type of active materials, along with the construction and structural materials, in the weapon.
- (2) The type and quantity of materials vaporized and sucked up into the fireball.
- (3) The use of radiological agents which produce nonstandard decay.
- (4) Fallout on fallout. When new fallout overlaps a fallout contaminated area, this area will have a nonstandard decay rate varying from location to location.

c. *Decay-Rate Determinations.* Nonstandard decay-rate determinations will be performed by the CBRE. When the CBRE has determined from actual monitoring data that the decay rate is nonstandard, the information will be disseminated to operating units. A unit operating in the field will always assume the decay is standard until informed otherwise. The procedures used by the CBRE to determine decay constants (n) are explained in paragraphs 125 through 132.

87. Calculations

a. *Nonstandard Decay Dose-Rate Calculations.* Dose-rate calculations in areas of nonstandard decay can be made, using the residual radiation decay (fallout) nomogram of figure 16. In using this nomogram for decay constants

other than standard (1.2), the times from the various decay constant scales must *always* be projected to the index scale before pivoting. The following examples explain the use of the nomogram for decay constants other than standard.

(1) Example problem 1.

GIVEN. $R_1 = 100$ rad/hr.
 $n = 0.8$.

FIND. R_t at $H + 7$ hours.

ANSWER. 20 rad/hr.

SOLUTION. Using figure 16, aline the hairline with the 7-hour tick-mark of the 0.8 time scale and equal values of the left and right reference lines. Pivot the hairline about its points of intersection with the index scale to the 100 rad/hr tick-mark on the R_1 scale. Read the dose rate at $H + 7$ at 20 rad/hr at the point of intersection of the hairline with the R_t scale.

(2) Example problem 2.

GIVEN. $R_1 = 2,000$ rd/hr.
 $R_t = 45$ rad/hr.
 $n = 2.0$.

FIND. The time at which the dose rate will be reduced to 45 rad/hr.

ANSWER. $H + 7$.

SOLUTION. Using figure 16 aline the hairline with 45 rad/hr on the R_t scale and 2,000 rad/hr on the R_1 scale. At the intersection of the hairline with the index scale, pivot (holding a sharp object at the intersection) and aline equal values on the left and right reference lines. Read 7 hours at the point of intersection of the hairline with the 2.0 time scale.

b. *Total Dose Calculations.* Total dose calculations for operations conducted in contaminated areas where the decay rate is *nonstandard* are made, using the following procedure:

- (1) A dose calculation is made, using the total dose (fallout) nomogram (fig.

17) and the procedures outlined in paragraph 81.

Note. The R_i value *must always* be determined for dose calculations by using the appropriate decay constant.

- (2) A correction factor (CF) is determined from figure 22 or 23 depending upon the decay constant. Figures 22 and 23 are nomograms showing the relationship of CF , n , T_e , and time of exit (T_x) where $T_x = T_e + T_s$. Figure 22 gives the correction factor for decay constants below standard and figure 23 gives the correction factor for decay constants above standard. The correction factor is found by placing the hairline on the time-after-burst curve for the known decay constant so that it passes through (connects) time of entry and time of exit. The correction factor is then read at the point of intersection of the hairline with the correction factor scale. Use of these nomograms is included in examples in *c* below.

- (3) The true dose can be determined by multiplying the dose calculated from figure 17 by the correction factor determined from the appropriate nomogram for the known decay constant. Symbolically, this is written:

$$D_t = D_s \times CF, \text{ where,}$$

$$D_t = \text{true dose,}$$

$$D_s = \text{calculated dose, using}$$

$$\text{standard decay, and}$$

$$CF = \text{correction factor, dependent}$$

$$\text{upon the true decay rate.}$$

c. Example Problems. The following example problems explain the use of the procedures outlined in *b* above.

(1) *Example problem 1.*

GIVEN. $R_i = 190$ rad/hr at $H + 2$ hours.

$$T_e = H + 2 \text{ hours.}$$

$$T_s = 8 \text{ hours.}$$

$$n = 0.9.$$

FIND. True dose to be received by personnel while staying in a contaminated area.

ANSWER. 610 rad.

SOLUTION. The dose rate at $H + 2$ must be normalized to $H + 1$. This is done by using figure 16 in the manner described in paragraph 80; read a value of 350 rad/hr from figure 16. On figure 17, using an R_i value of 350 rad/hr with the given values of T_e ($H + 2$) and T_s (8 hours), read a calculated dose of 380 rad. Find the correction factor from figure 22, using the decay constant of 0.9; place the hairline so that it passes through 2 hours (T_e) and 10 hours (T_x) on the 0.9 time-after-burst curve ($n = 0.9$). Read a correction factor of 1.6 where the hairline intersects the correction factor scale ($b(2)$ above). Find the true dose by multiplying the calculated dose by the correction factor.

Thus:

$$D_t = D_s \times CF$$

$$= 380 \text{ rad} \times 1.6$$

$$= 610 \text{ rad.}$$

(2) *Example problem 2.*

GIVEN. $D_s = 200$ rad.

$$T_e = H + 3 \text{ hours.}$$

$$T_s = 4 \text{ hours.}$$

$$n = 1.8.$$

FIND. True dose to be received by personnel while staying in a contaminated area.

ANSWER. 82 rad.

SOLUTION. Find the correction factor from figure 23, using the decay constant of 1.8; place the hairline so that it passes through 3 hours (T_e) and 7 hours (T_x) on the time-after-burst curve ($n = 1.8$). Read the correction factor of 0.41 where the hairline intersects the correction factor scale. Thus:

$$D_t = D_s \times CF$$

$$= 200 \times 0.41$$

$$= 82 \text{ rad.}$$

TIME
↓
HOURS
AFTER
BURST

CORRECTION FACTOR (LOW n)

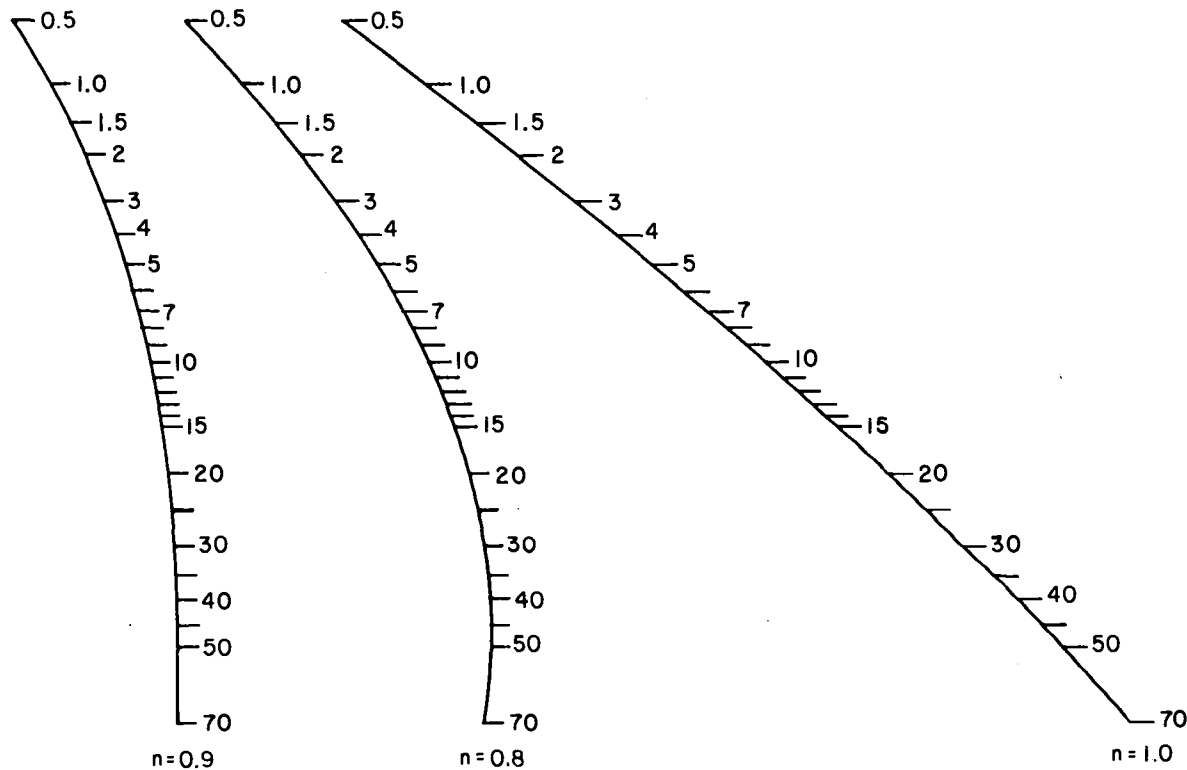


Figure 22. Correction factor for nonstandard decay (LOW n).

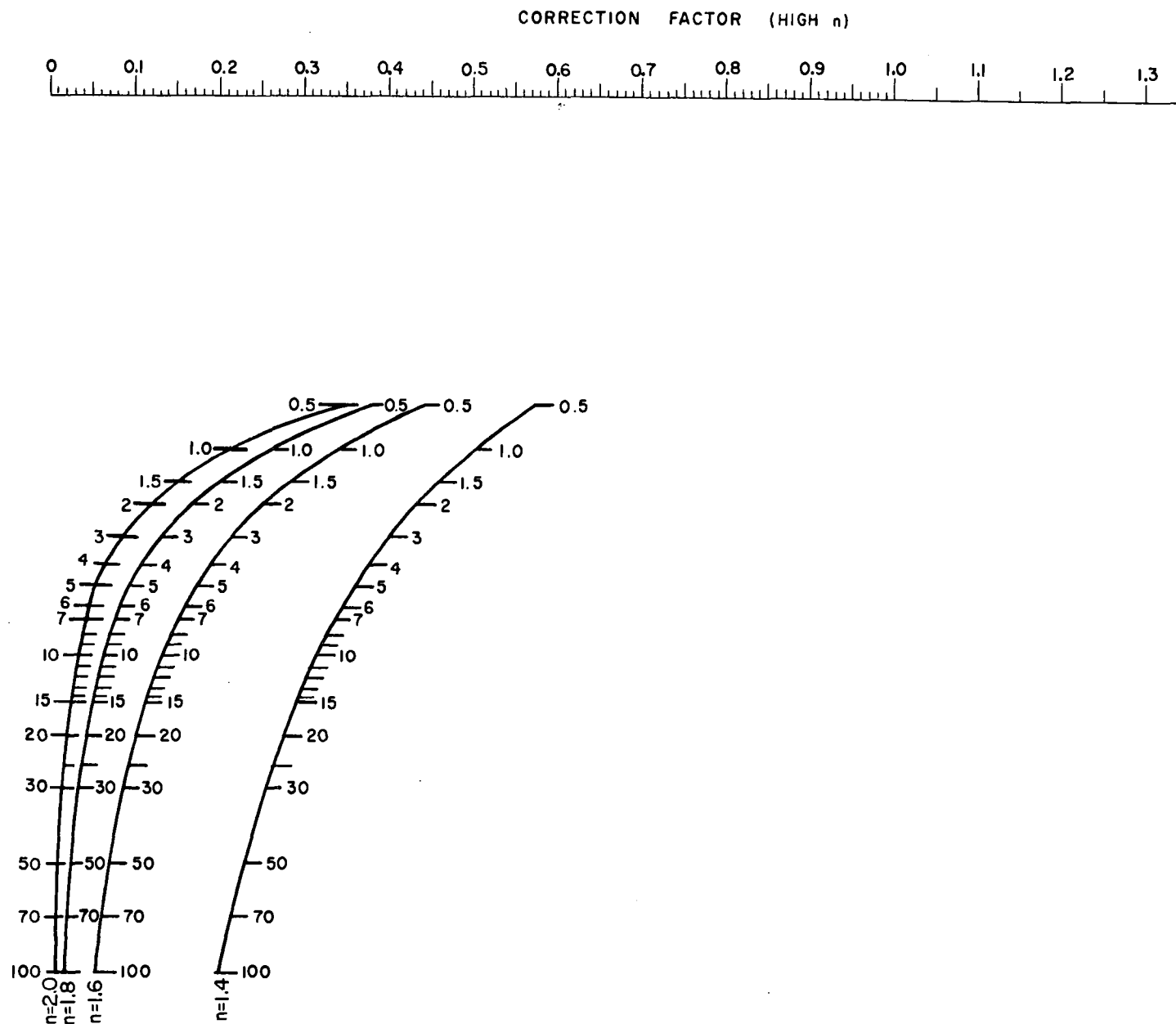


Figure 23. Correction factor for nonstandard decay (HIGH n).

Section III. INDUCED RADIATION

88. Nature of Induced Radiation

Neutrons are produced in all nuclear weapon detonations. Some of these neutrons may be captured by the various elements in the soil under the burst. As a result of neutron capture some of these elements become radioactive, generally emitting beta particles and gamma radiation for an extended period of time following an explosion. Beta particles are a negligible hazard unless the radioactive soil makes direct contact with the skin for an extended period of time. In this case, the beta particles can cause skin irritations varying from erythema to ulcerations. In contrast, gamma radiation readily penetrates the body and can cause radiation sickness and even death. Consequently, the external military hazard of induced radiation is determined substantially through an analysis of the intensity of the emitted gamma radiation. Induced radiation is not considered a militarily significant internal hazard because it is doubtful that the radioactive particles can be inhaled or ingested in great enough concentration to be dangerous.

89. Characteristics of Induced Radiation

The principal characteristics of induced radiation are—

a. Localized Symmetrical Pattern. The pattern of induced radiation is circular around ground zero. The dose rates within the pattern are highest at ground zero and decrease with distance from ground zero. The pattern is much smaller than the fallout pattern would be if the same weapon were burst on the surface. Weather conditions have no influence on the location and size of the pattern or the dose rate of induced radiation and there is no shifting of the pattern by surface winds. The pattern, if produced, will always be located around ground zero. The predicted magnitude of this pattern and the ground zero dose rates for any weapon are found in the contingent effects tables associated with the specific weapon and delivery system in FM 101-31.

b. Difficult to Decontaminate. Since the soil in the target area is made radioactive to a depth of about 0.5 meter, decontamination is difficult, requiring the removal of the top 10

centimeters of soil where most of the radiation exists. In contrast, fallout is a deposit of radioactive dust on the surface and can be removed with somewhat more ease than induced radiation. Both types can be covered by earth.

c. Persistent. The decay characteristics of induced radiation are considerably different from those of fallout. Fallout is a mixture of many different substances, all with different rates of decay. Induced radiation is produced primarily in aluminum, manganese, and sodium. Other elements either emit so little gamma radiation or decay so fast that they are less important. Within the first one-half hour after a burst, the principal contributor to induced radiation is radioactive aluminum. Almost all soils contain aluminum since it is one of the most abundant elements. Radioactive aluminum emits very high dose rates of radiation; however, within one-half hour after burst almost all the radioactive aluminum has decayed. Most soils also contain significant quantities of manganese which decay with a half-life of about 2.6 hours. From one-half hour after burst until 10 to 20 hours after burst, both manganese and sodium are the principal contributors to the radiation. After 10 to 20 hours, sodium, which decays with a half-life of about 15 hours, is the principal source of radiation.

90. Considerations at the Operational Level

a. General. A commander will always desire to expose his unit to as little induced radiation as possible. The commander may know the approximate ground zero of recent or planned nuclear detonations and will select, if possible, a course of action which will avoid the expected areas of induced radiation. However, enemy action, obstacles, or the attainment of significant tactical advantage may cause a commander to move his unit through an area of induced radiation or it may be encountered unexpectedly. The following is a discussion of aids available to the commander and some suggested courses of action.

b. Aids to the Commander.

(1) *Boundary and extent of area.* The boundary of the hazardous area of

induced activity is indicated by the 2 rad/hr reading ($H + 1$) on the survey meter. The maximum radius of this dose-rate contour is about 1,100 meters and it is usually substantially less. The most hazardous part of this area is a relatively small circle (radius of 300 meters or less) around ground zero.

- (2) *Indications of ground zero direction.* The circular symmetry of some types of damage such as scorching, tree blowdown, or other blast phenomena may be visible. In addition, the reverse sides of objects or shadowed objects normally will not be burned. Since the severity of these damage patterns increases in the direction of ground zero, examination of the damage may reveal the direction of ground zero.
- (3) *Radiological survey.* Radiological survey parties should habitually accompany the lead elements and continuously monitor the route of advance. Information obtained by these survey parties can be used to determine if induced radiation (2 rad/hr dose-rate contour) has been encountered, how the dose rate increases with direction of travel, and whether the maximum dose-rate point has been passed for any route selected through the area of induced radiation.

c. *Courses of Action.*

- (1) *Selecting a route.* Any route, whether a straight line or a peripheral course, which avoids the area in the vicinity of ground zero will reduce doses below those from a route which passes through or near ground zero. However, this option as to route selection may be influenced by the terrain. Obstacles formed by tree blowdown, fires, and building collapse, may limit not only the number of routes available but also the mode of movement; that is, on foot or in vehicles.
- (2) *Mode of crossing.* If there is an option as to the method of transportation to be used in crossing an area of induced

activity, it should be selected in the following priority:

- (a) Armored vehicles and personnel carriers.
- (b) Wheeled and tracked vehicles, preferably with sandbagged floors.
- (c) On foot.
- (3) *Maximum dose-rate point.* When crossing an area of induced radiation, the commander should note the point of maximum dose rate. At this point he is closest to ground zero, and, as a rough estimate, he can assume that his total traversal dose will equal two times the current dosimeter reading at the point of maximum dose rate; that is, assuming the dosimeter reading was zero before entering the area. Beyond this maximum dose-rate point, it will usually be just as safe (radiation-wise) to continue to advance or to move laterally away from ground zero rather than to withdraw. If the dose rate is becoming prohibitively high prior to reaching this maximum dose-rate point, the commander may change his route of advance or withdraw, depending upon the tactical situation.

d. *Occupancy of an Area.* Routine occupancy of an area of induced radiation is possible in from 2 to 5 days after burst. In the case of occupancy, low dose rates assume greater significance because of the indefinite period of exposure. A commander should seek the least contaminated region available, consistent with his mission, and only in unusual circumstances should he allow his unit to occupy an area for an extended period in which the dose rates are significantly over 0.2 rad/hr. A dose rate of 0.2 rad/hr results in an exposure of 5 rad/day, disregarding decay. Semipermanent positions in a region with levels as high as 2 rad/hr should be considered only in critical situations. During operations in a radiation field, the dosimeter should be checked frequently.

91. Decay Calculations

a. *Variable Decay.* The rate of decay of induced radiation is considerably different from that of fallout. The rate of decay of fallout is

dependent upon the fission products produced in the burst itself and can be calculated by using a constant decay law. On the other hand, soil composition is the most important factor in the decay of induced radiation. Since soil composition varies widely, even in a very localized area, the actual chemical composition of the soil must be known to be able to determine the rate of decay of induced radiation. For this reason, four types of soil have been selected to show the wide variance in the predicted dose rates and decay rates. See FM 101-31 for chemical composition of soils for the four soil types. Since the actual soil composition will not normally be known, soil type II has been chosen as standard for decay and total dose calculations. Soil type II will be used for all calculations until a comparison of the monitoring information versus the dose rates at various times from a nomogram gives an indication of the soil type in which decay approximates the actual dose rates.

b. Decay Nomogram. The decrease in the radiation dose rate can be calculated by the use of a nomogram. The residual radiation decay (induced) nomogram, figure 24, allows the user to predict the dose rate at any time if a dose rate at any time after the burst is available. The nomogram contains 4 scales which denote time after burst in hours for four soil types, I, II, III, and IV, as indicated above each scale. The scale for soil type II is indicated as an index scale and will be used in calculations when the soil composition is not known (*a* above). The R_i scale, at the right of the time scales, shows dose rates at $H + 1$; the R_t scale, at the left of the time scales, shows dose rates at times other than $H + 1$. The outside left and right lines are reference lines to be used in aligning the hairline. Use of the decay nomogram is shown in the examples below.

c. Example Problems. In working with nomograms, care should be taken to be as consistent as possible when joining values with the hairline. Be sure the hairline intersects the vertical line and the interpolated value (tick-mark) as closely as possible.

(1) *Example problem 1.*

GIVEN. $R_t = 150$ rad/hr at
 $H + 3$ hours.

FIND R_i .

ANSWER. 190 rad/hr.

SOLUTION. Since the soil type (composition) is not known, calculations will be performed on the soil type II (index) scale. Aline the hairline with the 3-hour tickmark on the soil type II (index) scale and equal values of the left and right reference lines. Pivot the hairline about its point of intersection ($H + 3$) with the index scale to the 150 rad/hr point on the R_t scale. Read the dose rate as 190 rad/hr at the point of intersection with the R_i scale.

(2) *Example problem 2.*

GIVEN. $R_t = 300$ rd/hr.

FIND. R_i at $H + 7$ hours when the soil composition approximates soil type III.

ANSWER. 50 rad/hr.

SOLUTION. Aline the hairline with the 7-hour tickmark on the soil type III scale and equal values of the left and right reference lines. Pivot the hairline about its point of intersection with the index scale to the 300 rad/hr point on the R_t scale. Read the dose rate as 50 rad/hr at the point of intersection with the R_i scale.

(3) *Example problem 3.*

GIVEN. $R_t = 280$ rad/hr.

FIND. Time when $R_i = 90$ rad/hr.

ANSWER. $H + 15$ hours.

SOLUTION. Since the soil type is not indicated, soil type II must be used for this calculation. Connect 280 rad/hr on the R_t scale and 90 rad/hr on the R_i scale. Read time as $H + 15$ hours on the soil type II (index) scale.

(4) *Example problem 4.*

GIVEN. $R_t = 200$ rd/hr.

FIND. Time when $R_t = 70$ rad/hr in soil type IV.

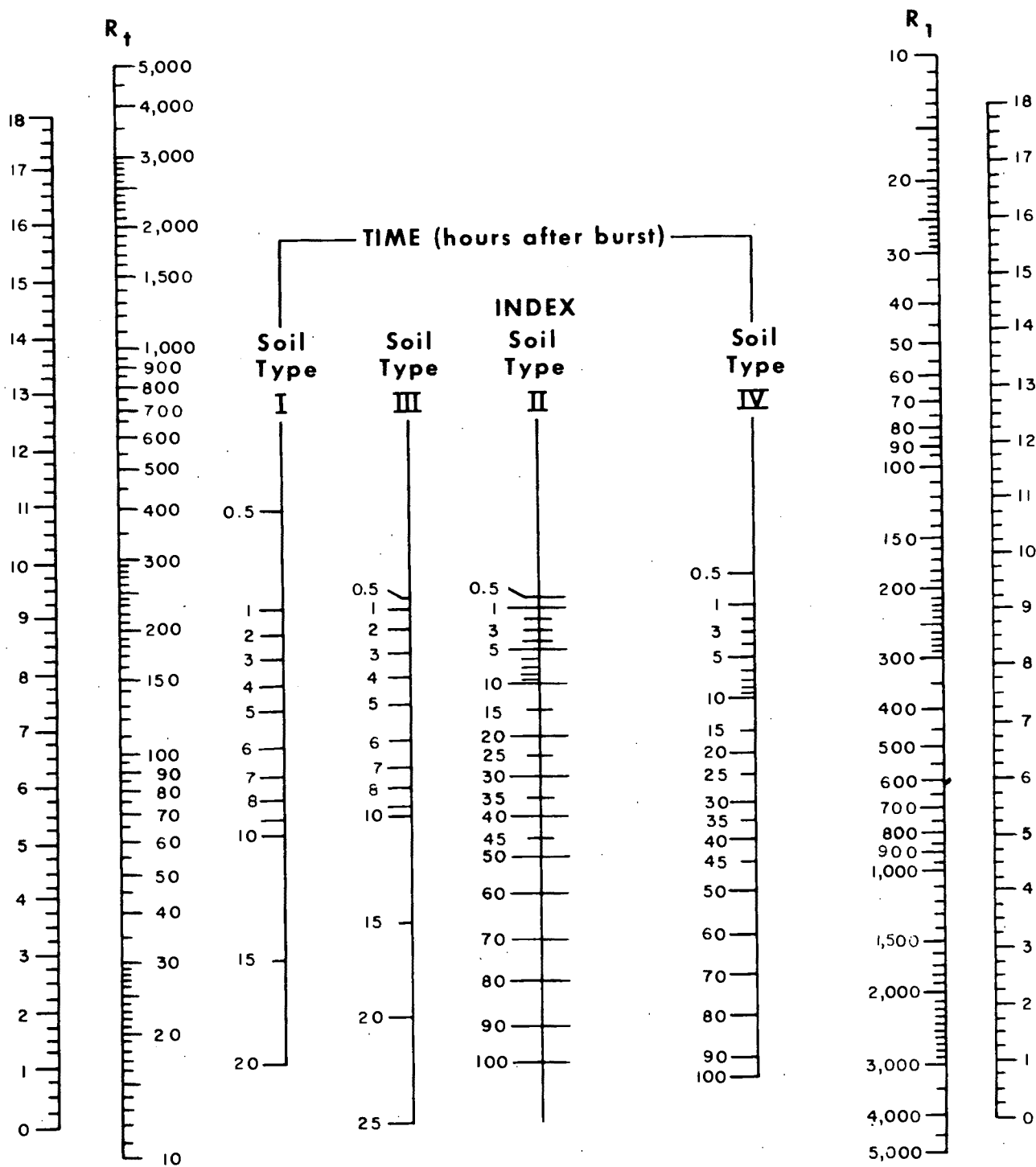


Figure 24. Residual radiation decay (induced).

ANSWER. $H + 10$ hours.

SOLUTION. Connect 200 rad/hr on the R_1 scale and 70 rad/hr on the R_2 scale. Holding the hairline firmly at its point of intersection with the index scale, align equal values on the left and right reference lines. Read time at $H + 10$ hours at the point of intersection with the soil type IV scale.

(5) *Example problem 5.*

GIVEN. Monitoring data from a unit occupying an induced radiation area:

Time (hours after burst)	Dose rate (rad/hr)
$H + 1$	250
$H + 2$	200
$H + 3$	150
$H + 4$	110

FIND. Soil type in which decay approximates the data above.

ANSWER. Soil type III.

SOLUTION. Connect 250 rad/hr on the R_1 scale and 200 rad/hr on the R_2 scale. Holding the hairline firmly at its point of intersection with the index scale, align equal values on the left and right reference lines. Check the intersection of the hairline with each of the four soil types to determine which is closest to $H + 2$; repeat this procedure, using the dose rates at $H + 3$ and $H + 4$. A review of the results will indicate that the decay of contamination from soil type III approximates the data given.

92. Total Dose Calculations

a. *Total Dose Nomogram.* The nomogram in figure 25 is used for predicting total dose to be received while in an induced radiation area. This nomogram relates total dose, dose rate 1 hour after the burst, stay time, and entry time. The two scales at the left show total dose and dose rate at $H + 1$, as indicated. Two time scales are positioned under stay time; the left scale is for soil types II and IV and the right scale is for soil types I and III. The index scale is a pivoting line which is used as

an intermediate step between D and R_1 and T_e and T_s . These symbols represent the same terminology as used in paragraphs 79 through 85.

b. *Essential Information.* If the available dose rate was taken at a time other than $H + 1$ hour, the R_1 value can be found by using the residual radiation decay (induced) nomogram (fig. 24) as described in paragraph 91c(1). The scale, soil types II and IV, under stay time will be used for total dose calculations if the soil type is not known. If the soil type is known, the appropriate scale under stay time will be used. It is possible to find any 1 value on the total dose nomogram if the other 3 are given, as illustrated in the examples below.

c. *Example Problems.*

(1) *Example problem 1.*

GIVEN. $R_1 = 140$ rad/hr.
 $T_e = H + 6$ hours.
 $T_s = 1$ hour.

FIND. D .

ANSWER. 72 rad.

SOLUTION. Since no soil type is indicated, use the scale for soil types II and IV under stay time. On figure 25, connect $H + 6$ hours on the T_e scale and 1 hour on the T_s scale (soil types II and IV) with the hairline. Pivot the hairline at its point of intersection with the index scale to 140 rad/hr on the R_1 scale. Read 72 rad on the D scale at the point of intersection with the hairline.

(2) *Example problem 2.*

GIVEN. $R_1 = 300$ rad/hr.
 $T_e = H + 6$ hours.
 $T_s = 1$ hour.
Soil type I.

FIND. D .

ANSWER. 70 rad.

SOLUTION. On figure 25, connect $H + 6$ hours on the T_e scale and 1 hour on the T_s scale (soil types I and III) with the hairline. Pivot the hairline at its point of intersection with the index scale to 300 rad/hr on the R_1 scale. Read 70 rad on the D scale at the point of intersection with the hairline.

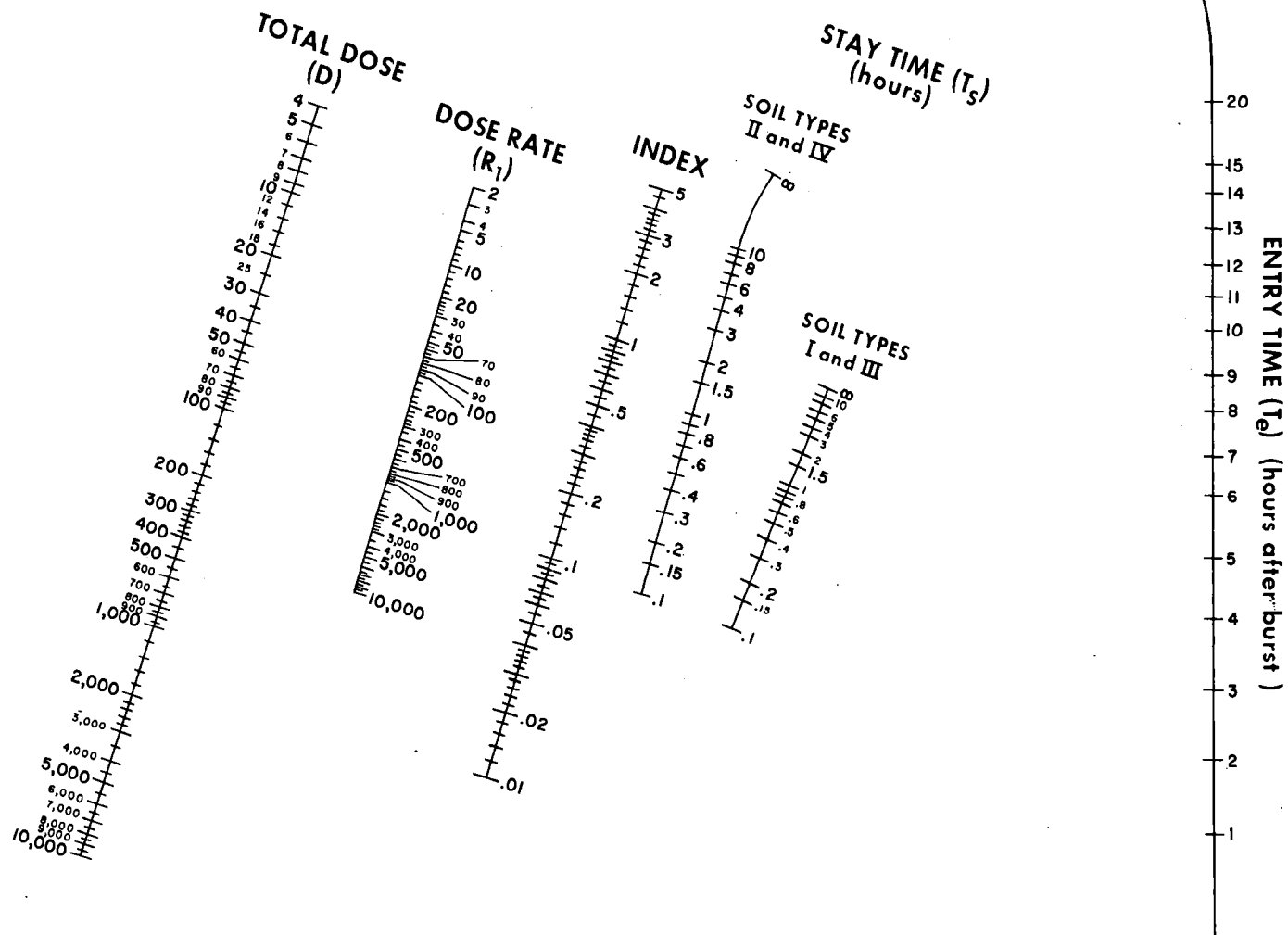


Figure 25. Total dose (induced radiation).

(3) *Example problem 3.*

GIVEN. $D = 25$ rad.
 $R_1 = 100$ rad/hr.
 $T_s = 0.4$ hour.
 Soil type III.

FIND. T_c .

ANSWER. $H + 3$.

SOLUTION. On figure 25, connect 25 rad on the D scale and 100 rad/hr on the R_1 scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 0.4 hour on the T_s scale (soil types I and III). Read $H + 3$ on the T_c scale at the point of intersection with the hairline.

93. Crossing an Induced Radiation Area

a. *General.* It may be necessary to cross an area in which there is induced radiation. The induced areas are generally small enough to be avoided if the tactical situation permits. If movement through or across an induced radiation area is necessary, the time required will usually be less than one hour.

b. *Average Dose Rate.* In calculations of total dose, it is necessary to determine an average dose rate since the dose rates will increase as the center of the area is approached and then will decrease beyond the center of the area. The average dose rate represents a mean value to which the individual is exposed during the

time of stay. A reasonable approximation of the average dose rate can be obtained by dividing the maximum dose rate predicted to be encountered by two. Symbolically, this is written as $R_{avg} = \frac{R_{max}}{2}$.

c. *Time of Stay.* Time of stay (stay time) must be calculated for crossing problems. Use the relationship of $T_s = \frac{\text{distance}}{\text{speed}}$.

d. *Example Problem.* An example problem is given below for calculation of dose when crossing an induced radiation area.

GIVEN. A crossing will take place as shown in figure 26 at $H + 20$ hours. Distance of the route across the area is 1.0 kilometer; the rate of speed during the crossing, on foot, will be 5 kilometers per hour.

FIND. D .

ANSWER. 20 rad.

SOLUTION. $R_{1(avg)} = \frac{R_{max}}{2}$
 $= \frac{1,000 \text{ rad/hr}}{2}$
 $= 500 \text{ rad/hr.}$
 $T_s = \frac{\text{distance}}{\text{speed}}$
 $= \frac{1.0 \text{ km}}{5 \text{ km/hr}}$
 $= 0.2 \text{ hour.}$
 $T_c = H + 20.$

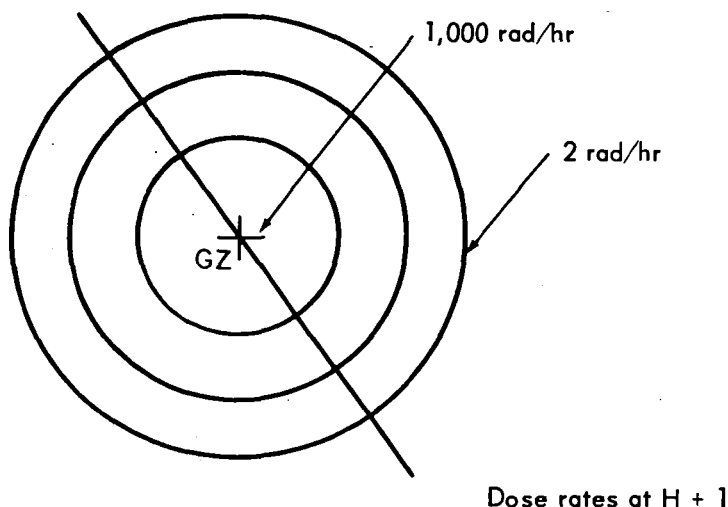


Figure 26. Example problem, crossing an induced radiation area.

On figure 25, connect 0.2 hour on the T_s scale (soil types II and IV) and 20 hours on the T_e scale with a hairline. Pivot through the point of intersection with the index scale to 500 rad/hr on the R_1 scale; read a total dose of 20 rad on the D scale

at the point of intersection with the hairline.

94. Shielding of Neutron-Induced Radiation

The transmission factors for neutron-induced radiation are the same as for fallout and are found in figure 18.

Section IV. MARKING OF CONTAMINATED AREAS

95. General

This section contains the procedures for the marking of radiologically contaminated areas. These procedures are designed both for the protection of personnel of the units responsible for the areas concerned and for the prevention of casualties or unnecessary exposure of individuals of other commands resulting from unknowingly traversing contaminated areas. The marking of a contaminated area will merely indicate the presence of a hazard, the extent of which either has been or must be determined by monitoring and survey. CBRE's at major headquarters will maintain current CBR situation maps which will portray the current contaminated areas and this information will be disseminated in accordance with local SOP. Consequently, all units and individuals will normally have access to radiological contamination information and the marking of contaminated areas will be intended primarily for the use of a relatively few individuals such as drivers and stragglers. Thus, the contamination marking will be limited to main access roads, main supply routes, and small long-term hazard areas such as neutron-induced areas.

96. Marking Procedures

Radiological contamination marking signs will be placed on main access roads leading into contaminated areas at points where the dose rate reaches 1 rad/hr measured at 1 meter above the ground. The signs will be moved daily, if possible, to account for radioactive decay. Traffic control personnel normally should be stationed near the radiation markers in order to verbally inform all personnel traversing the contaminated area of the extent of contamination and of the safe allowable stay time. How-

ever, in the absence of traffic control personnel, sufficient information will be placed on the sign to adequately warn all individuals traversing the contaminated area.

97. Signs

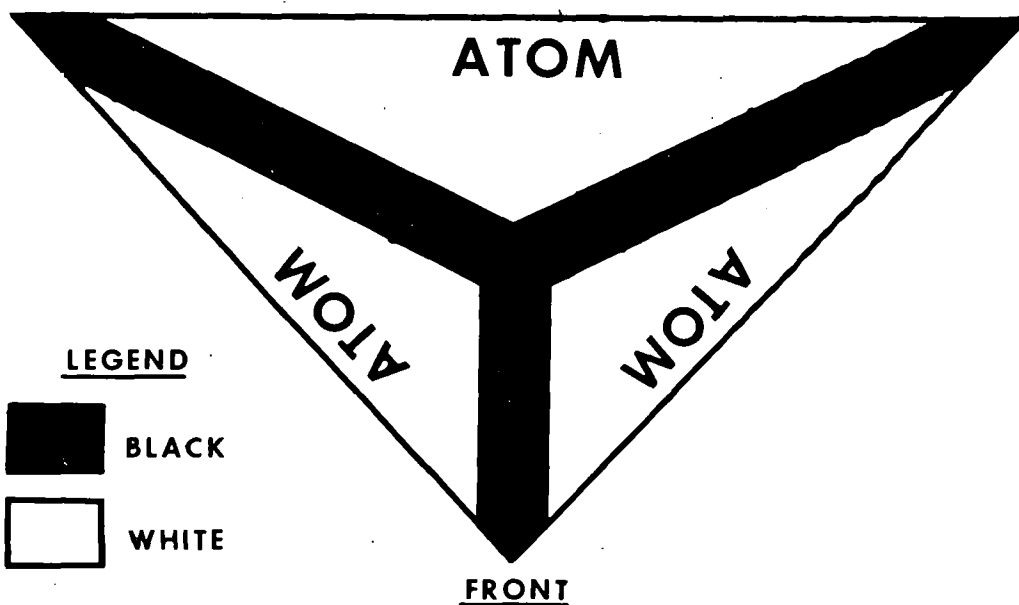
The radiological contamination marking sign will be in the shape of a right-angled isosceles triangle with a base of approximately 11½ inches and sides of approximately 8 inches. The front and rear of the sign will be as indicated in figure 27 with the following information entered on the rear by the section responsible for placing the radiological contamination marking sign:

- a. The dose rate.
- b. Date and time of dose-rate reading.
- c. The date and time of the burst that produced the contamination, if known.

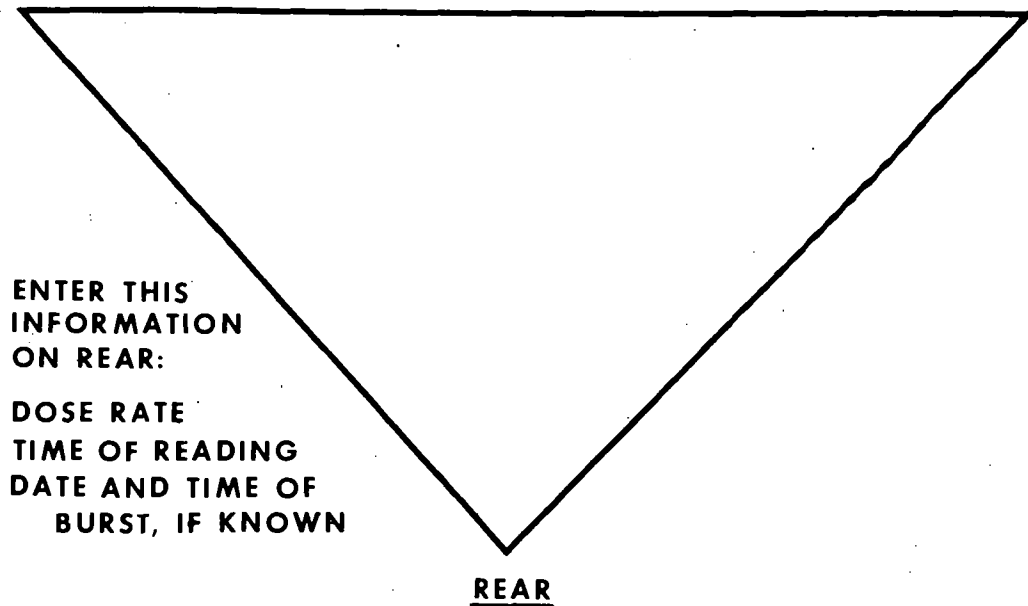
98. Guidance

a. It has been determined that the command responsible for an area is responsible for planning and maintaining the contamination marking signs. Commands leaving an area or otherwise giving up responsibility for an area will leave perimeter signs in place. The command taking over responsibility for the area will continue the daily movement of the signs or remove them when they are no longer necessary.

b. At the discretion of the commander, a radiologically contaminated area need not be marked when a military advantage would be obtained by not doing so. In such cases, positive measures will be taken to warn other friendly forces of the existence of the radiologically contaminated area.



SURFACE FACING AWAY FROM THE CONTAMINATED AREA



SURFACE FACING THE CONTAMINATED AREA

Figure 27. Radiological contamination marking sign.

CHAPTER 7

RADIATION EXPOSURE GUIDANCE

99. General

Military operations in nuclear war will be complicated by the necessity to control the exposure of personnel to nuclear radiation. The primary reasons for such control are to maintain the combat effectiveness of personnel and insure effective combat operations. The commander cannot be bound by any hard or fast rules on radiation exposure control; therefore, any control which is established should be flexible and should provide the commander with sufficient guidance to prevent overexposure unknowingly with least interference with the accomplishment of the mission.

100. Purpose

The purpose of the procedures outlined below is to provide the commander with guidance to aid in successful employment of his command on the nuclear battlefield with minimum exposure of personnel to nuclear radiation.

101. Definitions

The terms operation exposure guide (OEG), effective dose, reference dose, and rad, as defined in paragraph 3, should be reexamined for a clear understanding of the material in this chapter.

102. Effect of Control of Radiation Exposure on Operations

a. Control of radiation exposure may affect operations by influencing the commander's decisions in the selection of a course of action and of the units to be employed in a given operation. Continuous evaluation of unit radiation exposure levels is necessary to assist in making these decisions.

b. Radiation exposure should be controlled to the maximum extent possible consistent with

the mission. This may, on occasion, tend to restrict operations but if control is ignored, the results could be disastrous. If an operation exposure guide is established, it will aid in keeping radiation exposures at a minimum and thus assist in accomplishment of the mission. For example, an operation exposure guide could be used in selection of units with low effective doses to perform missions requiring exposure to radiation.

c. Without due consideration, it might be said that "an operation exposure guide of 20 rad, 60 rad, or 100 rad for one operation will not cause casualties." This may be true for a unit which has absorbed no previous radiation. However, if a unit already has an effective dose of 120 rad, an additional 80 rad might render it ineffective. If, on the other hand, a unit with an effective dose of 20 rad is used, the additional 80 rad would probably not render it ineffective. This points up the fact that operational records should continuously reflect the radiation status of units.

d. It is emphasized that it would be meaningless to establish *ONE* categorical value for an operation exposure guide that would be valid throughout a campaign because the establishment of an operation exposure guide for a particular unit is dependent upon the previous exposure history of that unit. An operation exposure guide must be established for each operation based upon radiation exposure status of the unit at that time and upon the combat situation.

103. Operation Exposure Guidance

a. *Categories of Exposure.* To effectively utilize radiation exposure records for rapid determination of a unit's potential to operate in radiologically contaminated areas, dose criteria

have been established in three categories. Full Remaining Radiation Service (FRRS), Limited Remaining Radiation Service (LRRS), and No Remaining Radiation Service (NRRS) (table IV). Criteria for each category are reference doses and have built-in biological recovery. It is emphasized that the values in tables IV and V should be used as *the best available estimates* in predicting the reaction of units to radiation exposure. The values in tables IV and V are based on the assumption that human injury due to radiation exposure consists of a reparable fraction which the body is capable of repairing at the rate of 2.5 percent per day.

Table IV. Dose Criteria for Placing Units in Remaining Radiation Service Categories

Period of time over which dose was received	Dose received		
	FRRS	LRRS	NRRS
1 week	Less than 50 rad	50-200 rad	Greater than 200 rad
2 weeks	Less than 60 rad	60-250 rad	Greater than 250 rad
1 month	Less than 75 rad	75-300 rad	Greater than 300 rad

- (1) *Full remaining radiation service.* Full remaining radiation service applies to a unit that has no dose or a militarily negligible radiation exposure history. Units in this category can be considered to have received no radiation; in other words, an exposure in the next operation that does not exceed the maximum exposure for this category should cause no loss of effectiveness.
- (2) *Limited remaining radiation service.* Limited remaining radiation service applies to a unit which has received a significant but not a dangerous dose of radiation. This category may include a dose range from just below the sickness threshold to one where the probability of sickness is approximately 0.15. If the situation permits, units in this category should be exposed less frequently and to smaller doses than FRRS units.

- (3) *No remaining radiation service.* No remaining radiation service applies to a unit which has already received a dose of radiation which makes further exposure dangerous. In other words, additional exposure in the immediate future would result in sickness and probably some deaths. If the situation permits, a unit in this category should not be exposed to any further radiation for at least 2 months.

b. Degrees of Risk. Even though it is meaningless to set one value as an operation exposure guide which will apply throughout a campaign or war, by using the "degree-of-risk" concept, additional guidance can be furnished the commander to assist in minimizing the number of casualties from nuclear radiation and in establishing an operation exposure guide for a particular mission. If the exposure status of units (FRRS, LRRS, NRRS) and the degree of risk the commander will accept are known, an operation exposure guide may be established by use of the degree-of-risk criteria (table V) for the conduct of effective operations in a radiologically contaminated area. Degrees of risk are in three categories: negligible risk, moderate risk, and emergency risk. These are the degrees of risk of becoming a casualty from exposure to radiation in an immediate short-time (1- to 7-day) operation. A *negligible risk* practically assures the commander of the complete safety of his troops. A *moderate risk* is the greatest degree of risk to be considered for units that are expected to perform at peak efficiency after exposure. An *emergency risk* is that degree of risk which is to be considered only when the situation demands that it be accepted. (For validity and use of table V, see explanation given in *a* above.)

- (1) *Degree-of-risk criteria for FRRS units.* Since units which are in this category can be considered as having received no radiation, the commander has more flexibility in using these units for missions where high degrees of risk exist without extreme curtailment of future capability. For example, if the emergency risk of 100 rad (table V) is accepted for a unit in this category of units and 100 rad is actually received by the unit during a

Table V. Degree-of-Risk Criteria

Status	Criteria
FRRS units	Negligible risk — Less than 20 rad Moderate risk — 20 to 100 rad Emergency risk — Greater than 100 rad.
LRRS units	Degrees of risk for this category will be either <i>moderate</i> or <i>emergency</i> depending upon the previous unit exposure history. For example, units whose exposure history does not exceed the limits shown below may receive up to 50 rad without exceeding <i>moderate</i> risk: 50 rad in 1 week 60 rad in 2 weeks 75 rad in 1 month <i>Emergency</i> risk for this category will be an exposure in excess of 50 rad when the previous exposure is equal to or greater than the above limits.
NRRS units	All future exposure is considered to be <i>emergency</i> risk.

particular operation, the greatest curtailment for future employment would be placing the unit in an LRRS category.

- (2) *Degree-of-risk criteria for LRRS units.* Since units in this category are considered as having received a significant but not a dangerous dose of radiation, any additional radiation received will be significant and therefore there can be no negligible risk criteria for this category of units. For this category of units, the degree of risk will be either moderate or emergency depending on the dose previously received. If previous exposure history shows higher levels than those depicted in table V, the degree of risk may be considered emergency. In such cases, determination of degree of risk will be made by the surgeon based upon evaluation of the previous exposure records of the units.

- (3) *Degree-of-risk criteria for NRRS units.* Since units in this category are considered as having received a dose which would make further exposure dangerous, any exposure would be considered emergency risk.

c. *Numerical Designation of Operation Exposure Guide.* The designation of the numerical

value of operation exposure guides will be established by battalion and higher level only. On occasion, to insure the effective use of his troop units in accordance with his plans, the division commander may direct his brigades and battalions concerning the operation exposure guide.

104. Radiation Exposure Records

The operation exposure guide concept requires that radiation exposure records be maintained on all units. The most realistic exposure records can be determined at the platoon level because companies are often so deployed that the platoons may not be located in areas of equal radiation dose rates or remain in these areas for like periods of time. In this case, an average of platoon doses would not reflect the true exposure of the company and therefore could result in casualties to a platoon with a high exposure history if all platoons are required to operate in a high dose-rate area at a later time.

a. *Reporting Procedures.* Unit radiation exposure records are normally maintained at battalion and higher level. Since this concept calls for platoon radiation exposure information and the company does not have the capability to properly evaluate these records, battalion will maintain radiation exposure records down to and including the organic and attached platoon.

Reports on the radiation exposure status of small units are not normally forwarded higher than battalion. Battalion will forward to division and brigade only the data concerning the effectiveness of the command; that is the percentage of the battalion in each category of exposure. This information will assist both the division commander and the brigade commander in establishing operation exposure guides, degrees of risk, and composition of task forces for missions requiring further radiation exposure. Within the division, exposure data are processed as follows:

- (1) Tactical dosimeters (currently issued on the basis of two per platoon) will be read daily or after each operation.
- (2) Average readings of platoons will be determined and reported to company.
- (3) Companies will report platoon readings to battalion.
- (4) Battalion will post readings daily in increments of 10 rad on charts similar to table VI and determine category of exposure of each platoon and the average category for the company.
- (5) Battalion will determine percentage of the command in each category of exposure and forward this information to brigade as part of the periodic operations report. The percentage of the command will be determined as follows for each category of exposure:

Percentage of battalion in category _____
(enter FRRS, LRRS, NRRS, as applicable)

$$= \frac{\text{No. of plat in that category} \times 100}{\text{Total No. of plat in battalion}}$$

- (6) Brigade will collate the radiation status of the supporting platoons and companies which have been attached to the brigade. A consolidated report of all the elements within the brigade will be forwarded to division.

b. Radiation Dose Status Chart. Since the OEG concept calls for maintenance of platoon radiation exposure records, the exposures must be collated and translated into usable data. To provide a rapid means of evaluating the exposures, the radiation dose status chart (table

VI) is used. All organic and attached platoons in the battalion are listed in the platoon column. The dose received, in units of 10 rad, is posted daily or after each exposure and is indicated by an upright tally mark: || for 20 rad, |||| for 40 rad, |||| | for 60 rad, and so on, in the appropriate date column. By using the criteria from table IV, FRRS, LRRS, or NRRS is determined and entered in the radiation status column. For example, on 7 June the chart may look like table VI. The 2d platoon of company A received 20 rad on 1 June, 20 rad on 2 June, and 40 rad on 7 June, a total of 80 rad in one week. Note that even though the platoon was FRRS at the beginning of the period, on 7 June it became LRRS based on criteria of table IV. The average company radiation status is posted below the individual platoon status. When there is no large difference (radiation-wise) between platoons in a company, the company radiation status will assist the staff in conducting its operations. Since the radiation status may change daily, charts covered with acetate will assist in reducing the number of charts necessary for maintenance of current radiation records.

105. Effective Dose

As time passes, the body recovers from a portion of the radiation which has been received. The effective dose is, for all practical purposes, the unrecovered dose. For example, a dose of 75 rad received over a period of 30 days at 2.5 rad each day is theoretically the same as absorption of a dose of less than 50 rad on the thirtieth day. In other words, on the thirtieth day the effective dose is less than 50 rad although a total dose of 75 rad has been absorbed. Similarly, if a dose of 75 rad is received on the first day of a 30-day period and no subsequent radiation is absorbed for the remainder of the period, at the end of that time the effective dose would be less than 50 rad. For prolonged exposure or for calculating the effective remaining radiation dose, the currently accepted formula is a recovery rate of 2.5 percent of the remaining dose per day.

106. Category Determination

a. Example. For an understanding of category determination, consider the status of the 2d platoon of company A as depicted in table

Table VI. Radiation Dose Status Chart, Month 6

Platoon	Company	Date								Present radiation status	Remarks
		1	2	3	4	5	6	7	30		
A1	A									LRRS	FRRS on 1 June LRRS on 7 June
A2										LRRS	FRRS on 1 June LRRS on 7 June
A3										LRRS	FRRS on 1 June LRRS on 7 June
A4										FRRS	FRRS on 1 June FRRS on 7 June
										LRRS	Company became LRRS on 7 June
Engineer Platoon										FRRS	FRRS when attached on 2 June

Note. The marks in the date columns are upright tally marks, each representing 10 rad.

VI. If the 2d platoon is LRRS on the seventh day of the 30-day period, and does not receive any radiation during the remainder of the period, at the end of the 30 days it will have an effective dose of less than 50 rad. It can then be reclassified as FRRS.

b. Guidance. The status of each unit should be reevaluated periodically, and in every case at least every 30 days, to determine any change in status which could cause placement in a different category. That is, additional exposure may cause a unit to be placed in a category which would not allow immediate employment in an operation in which it would be exposed to further radiation without accepting an emergency risk. This determination may be made by reading either personal or tactical (unit) dosimeters at which time the appropriate cate-

gory is assigned the unit, based on the effective dose of the majority of the troops. For example, if a majority of the personnel has an effective dose of 50 to 200 rad after one day of operations, the unit would be classified as LRRS. It is emphasized that the category and degree-of-risk tables (tables IV and V), serve only to guide the commander and his staff.

107. Chemical, Biological, and Radiological Element Responsibilities

The CBRE at division will maintain on a daily basis the radiation exposure status of each battalion within the division. The exposure status will be obtained from the periodic operations report and will reflect the percentage of each battalion in each category of exposure. This information will enable the CBRE to

provide the commander with estimates of situations which could produce radiological hazards to the battalions of the division.

108. Surgeon

After the staff surgeon learns the degree of risk the commander is willing to accept for a particular operation, he coordinates with the CBRE for the current radiation status of the unit involved. If detailed radiation status information is required the surgeon should contact the battalion concerned. He then determines what level of radiation may be received within this degree-of-risk concept. The surgeon advises the commander that a certain dose level may be considered as the operation exposure guide for that particular unit.

a. He may advise that for units in NRRS category any further exposure is considered an emergency risk.

b. For units in the LRRS category, the risk could be either moderate or emergency, depending on the dose previously received.

c. If the commander specifies only a negligible risk, then only those units in FRRS category should be considered and the surgeon may suggest an operation exposure guide of 20 rad. If the commander indicates he will accept an emergency risk, the operation exposure guide will be set at a higher level.

d. The surgeon's understanding of the effect of radiation on health is of particular importance in evaluating the effect of further radiation on troops who have already been exposed to radiation.

109. Establishment of an Operation Exposure Guide-Example

It is 6 October. The battalion commander plans to commit company B on 7 October in a radiologically contaminated area. He will accept a moderate risk. An operation exposure guide must be established during the planning phase. Before the exposure guide is established, the commander consults the S3 and the surgeon. The radiation dose status chart (table VII) is checked and the radiation status of company B is determined to be FRRS. Estimates on the hazard in the contaminated area are requested from the division CBRE. The surgeon notes that FRRS corresponds to an effective dose of less than 50 rad in 1 week (table IV). Since a moderate risk is acceptable, the maximum total dose allowed will be 100 rad (table V). The surgeon may suggest an operation exposure guide of 60 rad, the difference between the maximum dose of 40 rad for company B (table VII) and 100 rad, the moderate risk for FRRS units. If the status chart shows another company has no previous exposure, this company could be committed and an operation exposure guide of 100 rad could be set for it.

Table VII. Radiation Dose Status Chart, Month 10

Platoon	Company	Date								Present radiation status	Remarks
		1	2	3	4	5	6		31		
B1	B									FRRS	
B2										FRRS	
B3										FRRS	
B4										FRRS	
										FRRS	
C1										FRRS	
C2										FRRS	
C3										FRRS	
C4	C									FRRS	
										FRRS	

Note. The marks in the date columns are upright tally marks, each representing 10 rad.

CHAPTER 8

RADIOLOGICAL OPERATIONS OF A CBRE

Section I. INTRODUCTION

110. General

a. Purpose. The CBRE of a tactical operations center supervises and coordinates the command radiological intelligence effort as part of its mission. This chapter establishes the techniques and procedures to be used by the CBRE to perform this part of its mission.

b. Applicability.

- (1) This chapter is written for the CBRE located at division, corps, and field army, and for the CBR Center Team (JA), or equivalent, organized within the TOE or TD of equivalent administrative commands.
- (2) This chapter is applicable in part to the radiological functions which are accomplished at brigade, battalion, and similar organizations. These functions are accomplished within S2 staff responsibility and are supported as necessary by control parties organized within the TOE and TA. At these headquarters, only a minimum of information processing is accomplished; the radiological functions normally are reduced to direction and control of the information collection effort and to the use of radiological intelligence produced by higher command echelons.

111. Assumptions

a. Doctrine. Doctrine concerning the tactical impact of large-area contamination is based upon the following assumptions:

- (1) The large-area contamination of most significance will be fallout which will decay at the standard rate and which can be related to a known nuclear burst.

- (2) Neutron-induced hazards are expected to be of little significance within the limits of the discussion of paragraph 11b.

- (3) Radiological agents will be used sparingly if at all.

b. Approach. Operational decisions based upon the assumptions of *a* above can be expected to be valid in most cases. The staff chemical officer exercises staff responsibility for determination of the validity of these assumptions with the CBRE representing his operational capability; thus, the CBRE must continually be alert to indications that the assumptions are not valid and be capable of functioning in special cases. For this reason, this chapter is written to provide a CBRE capability for any type of large-area contamination even though the more refined procedures such as apparent H-hour determination and non-standard decay considerations will not be essential for most tactical applications.

112. Organization

a. Support. The command support required for the radiological intelligence collection effort is established by paragraph 7.

b. CBRE Capability. In order to accomplish the mission of supervision and coordination of the radiological intelligence effort, the CBRE must maintain a continuous capability to—

- (1) Receive and transmit information.
- (2) Perform computations necessary to convert basic information to the forms required for various calculations.
- (3) Plot and display assembled information.
- (4) Evaluate assembled information.
- (5) Disseminate radiological intelligence.

c. CBRE Organization for Radiological Functions.

- (1) *Personnel.* The personnel of a CBRE, as delineated in the appropriate TOE, consists of the CBRE director, chemical operations sergeant, computers, and plotters. These personnel may be supplemented by attachment of CBR Center Teams (JA) when 24-hour operation is required.
- (2) *Duties.* See figure 22, FM 101-5, insert 7.

(a) The CBRE director—

1. Supervises and directs all functions of the CBRE, under the supervision of the chemical officer.
2. Analyzes incoming monitoring data to determine whether the radiological situation is described adequately and recommends the feasibility of a survey to the chemical officer.
3. Briefs survey parties on their specific missions when the primary or centralized method of control is used.
4. Analyzes incoming survey data and revises survey plans as required.
5. Directs the activities and movements of all survey parties which report directly to the CBRE control party.
6. Applies mathematical methods necessary to solve problems regarding unusual situations as they arise and prepares simplified tables or graphs as necessary for use by the computer and plotter in correcting data.

(b) The chemical operations sergeant—

1. Assists the CBRE director in the overall supervision of the CBRE.
2. Trains and cross-trains enlisted members of the CBRE.
3. Coordinates the functions of the enlisted members of the CBRE and monitors their output.
4. Insures accuracy in all functions by periodically checking the work of the computers and plotters.
5. Reviews all records, reports, maps,

sketches, etc., prior to inspection by the CBRE director.

6. Monitors all information disseminated by the CBRE.

7. Assists in the controlling of radiological surveys.

(c) The computer—

1. Calculates transmission factors or correlation factors, as applicable, from data reported by survey parties or monitors.
2. Selects appropriate correction factors for decay from tables, graphs, or nomograms.
3. Converts all useful data to ground dose rates at a reference time by using the appropriate transmission/correlation factors.
4. Performs duties of the plotter as required.

(d) The plotter—

1. Plots data that have been corrected by the computer as necessary to obtain desired dose-rate contours.
2. Draws dose-rate contours from plotted data.
3. Performs entire task of making fallout predictions, using input data supplied.
4. Receives and records incoming survey and monitoring data as assigned.
5. Transmits instructions to survey parties and monitors as assigned.
6. Decodes and encodes messages as required.
7. Performs duties of the computer as required.

d. Cross Training. The number of individuals available for accomplishing the CBRE radiological functions are normally limited and the problems presented are varied and urgent. It is, therefore, essential that these personnel be cross-trained to perform all CBRE radiological functions.

e. Equipment. The type of equipment required to conduct radiological functions may be found in the TOE of organizations authorized an organic CBRE or in TOE 3-500E and TA 20-8.

Section II. CONCEPT OF OPERATIONS

113. General

Radiological contamination on the nuclear battlefield may cover large areas, may occur in many locations, and may be in varying stages of decay. Initial detection of new contamination will probably be in the form of contact reports from units, patrols, or observers. These reports will alert the command to the presence of a previously undetected hazard and cause a new series of orders and requests to be initiated for radiological information. These orders and requests will be superimposed upon the intelligence cycle which is already functioning for older contaminated areas. Thus, the supervision and coordination of the radiological intelligence effort will be a continuing process for the CBRE.

114. Initial Requirements

In order to provide radiological intelligence as rapidly as possible, it is imperative that all possible information be obtained and maintained in advance. These types of information are as follows:

a. *Check Point Overlay.* The check point overlay for aerial survey planning will be prepared as areas are assigned or as areas of interest change.

b. *Wind Vector Plot.* A current fallout wind vector plot will be maintained for fallout prediction.

c. *Enemy Nuclear Capability.* A summary of enemy nuclear capability will be maintained, if feasible, to assist in yield estimation.

d. *Operations Map.* An operations map showing area responsibility of major subordinate commands will be maintained for survey and monitoring planning purposes.

e. *Nuclear Weapon Burst Record or Overlay.* A record or overlay will be maintained showing as a minimum the location and time of burst and, if known, the yield and type of all bursts that have occurred within areas of interest.

f. *Points, Routes, or Areas of Operational Interest.* A listing or overlay showing points, routes, or areas where contamination could seriously affect accomplishment of the mission will be maintained for survey and monitoring planning purposes.

g. *Equipment and Training Status.* A record of equipment status and training status of available monitors, survey parties, and subordinate control parties will be maintained for survey and special report planning purposes.

115. Sources of Contamination

The path taken by the intelligence cycle for areas of suspected contamination will depend upon the operational situation and upon the type and source of contamination. The operational situation will determine the urgency with which the cycle must function and the degree of detail which must be provided. The type and source of contamination will determine the intelligence requirements and sequence of calculations to be performed. The types and sources of radiological contamination are as follow:

a. *Induced Contamination.* Contamination resulting from a nuclear burst where the contamination *can* be related to a specific nuclear burst where fallout did not occur, or contamination localized around an obvious ground zero area.

b. *Fallout (Known Weapon).* Contamination arriving or identifiable as fallout which *can* be related to a particular nuclear burst.

c. *Fallout (Unknown Weapon).* Contamination arriving or identifiable as fallout which *cannot* be related to a particular nuclear burst.

d. *Contamination (Unknown Source).* Contamination identifiable as induced, fallout, or radiological agent which *cannot* be related to a known source.

e. *Combinations of the Above.*

116. Operational Procedure

a. *General.* The general concept of operations for the CBRE is that it acts as an evaluation agency through which all available CBR information is channeled. From this information, a CBR situation map showing areas of responsibility and interest will be developed and maintained. This map should contain all suspected, detected, and evaluated areas of radiological contamination and thus provide a basis for warning units and for development of required intelligence.

b. Information Flow. The information flow which provides the basis for accomplishing the evaluating function is established in paragraph 7. The automatic information flow will normally provide sufficient information to establish suspected areas of contamination. The CBRE will continually analyze this information so that timely warning can be provided to affected units and necessary procedures can be initiated to insure orderly and rapid development of knowledge about a particular contaminated area. Knowledge about a particular contaminated area should be developed so that classification of the contamination in the area will progress from "suspected" to "detected" to "evaluated" as described in paragraph 117. A summary of the types of information available to support the requirements for analysis and development of information follows:

- (1) *Automatic reports.*
 - (a) Upper air wind data.
 - (b) Nuclear burst reports.
 - (c) Monitoring reports.
- (2) *Other reports.*
 - (a) Survey reports.
 - (b) Series of monitoring reports.
 - (c) Summary reports in specified areas of responsibility.
 - (d) Verification reports at specified locations.

117. Classification of Contamination

a. Suspected Contamination. New contamination should be suspected to exist and the suspicion should be investigated under the following conditions:

- (1) When a nuclear burst occurs.
- (2) When contact reports indicate contamination in a previously unsuspected area.

b. Detected Contamination. Adequate warning of a contamination hazard to the command, particularly fallout warning, will require information indicating that contamination exists or is likely to occur and knowledge of the general area involved. Under the conditions indicated below, a contamination hazard is considered detected. This detection provides the basis for issuing a radiological contamination warning or a fallout prediction and for

planning the collection effort necessary to evaluate the contamination hazard.

- (1) A suspected neutron-induced contamination hazard is considered detected when monitoring or survey information indicates surface contamination localized around a ground zero area with no fallout formation. The arbitrary limit of hazardous induced activity is established as the 2 rad/hr dose-rate contour determined at 1 hour after the burst ($H + 1$). The radius of this contour is not expected to exceed 1,100 meters for yields of 100 KT or less at times later than one-half hour after burst.
- (2) A fallout contamination hazard is considered detected when nuclear burst reports indicate that fallout will probably occur from a nuclear burst (obvious surface burst), when observers report crater formation or extensive scouring, or when contact reports indicate fallout is actually occurring. The probable area that will be affected by fallout will be determined by a poststrike fallout prediction.
- (3) Other radiological contamination hazards are considered detected when contact reports indicate the presence of the contamination hazard and monitoring reports, hasty survey, or reconnaissance indicate the general area affected.

c. Evaluated Contamination. Evaluation of a radiological contamination hazard may be considered sufficient when the following factors are known or reliably estimated:

- (1) When the perimeter of militarily significant contamination is determined.
 - (a) For new contamination (H -hour to $H + 29$ hours), this will be as specified in *b*(1) above for induced contamination; for fallout this will be the one-hour after burst ($H + 1$) dose-rate contour of 10 rad/hr.
 - (b) For old contamination, the perimeter will be determined based upon the conditions existing at the time.
- (2) When H -hour or a reference time is established.

- (3) When the decay rate is known.
- (4) When information about dose rates inside the perimeter is sufficient to make the dose calculations required for evaluation of the operational impact of the hazard.

118. Processing of Information

During the evaluation process, monitoring or survey reports will provide dose-rate information about the contaminated area. This dose-rate information must be converted to the ground dose rates existing at a reference time (normally $H + 1$ for all contamination except radiological agents). To accomplish processing and to calculate doses from the resulting intelligence, a reference time (H-hour) must be established and the decay rate of the contamination determined. The procedure to be followed in determining these two factors will depend upon the source of the contamination (par. 115) and the operational situation existing at the time. In fluid or vague situations, as normally will be the case for division offensive operations, it is unlikely that detailed processing such as described in paragraphs 125 through 132 will be required. A rough estimation of H-hour and an assumption of standard decay will be sufficient to allow evaluation of a radiological contamination hazard for the 6- to 18-hour period which will be of interest to the division; detailed processing will probably be delayed until the area of hazard passes into corps or army area of responsibility. A summary of the development of radiological contamination information as performed by the CBRE is presented below.

a. H-Hour Estimates.

- (1) *Induced contamination (known weapon)*. In the case of induced contamination from a known weapon, H-hour will be known or can be reasonably estimated and the decay rate in the contaminated area can be determined. Dose-rate information can be normalized to $H + 1$, a pattern prepared, and calculations made.
- (2) *Fallout (known weapon)*. In the case of fallout from a known weapon, H-hour will be known; the decay rate will be unknown but may be assumed

to be standard during the initial information processing. Errors in developing radiological contamination patterns by assuming standard decay (par. 86) will be negligible during the first 2-hour period after H-hour. However, a decay-rate estimation will be required for processing information taken after $H + 2$ and a decay-rate determination will be required for dose calculations and hazard evaluation.

- (3) *Fallout (unknown weapon)*. In the case of fallout from an unknown weapon, neither H-hour nor the decay rate will be known initially and cannot be determined until monitoring information (par. 122) is available over a long time interval (20 or more hours) unless laboratory facilities are available for analysis of the actual contamination (10 hours). However, when monitoring information (par. 122) taken over a 3- to 4-hour period is available, an apparent H-hour estimation can be made by assuming standard decay. Dose calculations or patterns developed from the apparent H-hour estimation are generally valid for a period of time equal to twice the time period over which monitoring information was obtained for the apparent H-hour estimation. The procedure used for identifying fallout patterns from an unknown weapon is described in the following example.

EXAMPLE. A fallout hazard is detected but cannot be related to a known nuclear weapon burst. New orders and requests are initiated and information is collected from 0800 to 1100 hours. About halfway through the collection cycle, 0930 hours, normalizing factors can be developed. About one-half hour after the end of the collection cycle, an apparent H-hour estimation can be made by assuming standard decay and the contamination pattern of 0930 hours can be normalized to the appropriate reference time. Calculations from this pattern will be valid until 1700 hours ($1100 +$

2(1100—0800) = 1700). By 1700 hours a more precise apparent H-hour determination can be made. The pattern is then renormalized to the more precisely determined reference time and the hazard is considered identified until 1100 hours of the next day (1700 + 2(1700—0800) = 1100 hours next day). This procedure is repeated unless a decay rate is determined by laboratory or field procedures at which time a true H-hour determination can be made and the hazard can be considered identified with a normal surveillance effort.

- (4) *Contamination (unknown source)*. In the case of contamination from an unknown source, the procedure is the same as for (3) above.
- (5) *Combinations of the above*. It is quite probable that contaminated areas on the nuclear battlefield will be recontaminated by new contamination; for example, fallout on fallout. Induced contamination will always be present around ground zero of a fallout-producing nuclear burst. Thus, the CBRE must be prepared to identify combinations of the various forms of radiological contamination. In overlap areas, the new contamination will usually be the predominant factor and dose calculations or hazard evaluations, using H-hour and decay rates of the new contamination will be sufficiently accurate. For the induced contamination around ground zero of a fallout-producing nuclear burst, the fallout will provide the dominant hazard for the first 6- to 12-hour period after which the hazard in the vicinity

of ground zero must be reevaluated. Similarly, new fallout occurring on older (more than 12 hours old) fallout in an area will provide the significantly changing part of the contamination, with the older contamination merely adding an essentially constant dose rate. In overlap areas where one form of contamination is not dominant, special decay-rate determinations will be required for evaluation of the overlap area. In this event, identification of contamination overlap areas will follow the procedures given in (3) above for a fallout contamination hazard from an unknown weapon and these overlap areas will require careful surveillance.

b. Plotting. As incoming information is processed, it is plotted on the radiological situation map by use of the procedures established in paragraphs 133 through 140.

c. Presentation and Dissemination. Data from the radiological situation map is converted to the form necessary for intelligence reports and disseminated. Discussions of the methods used are contained in paragraphs 76 through 78 and 141 through 143.

d. Maintenance of the Radiological Situation Map. Theoretically, once a radiological hazard has been identified, the contamination existing at any future time can be calculated. However, weathering and inaccuracies in initial identification make this approach unrealistic and frequent surveillance of contaminated areas is essential. The frequency and detail of the surveillance effort will be determined by the reliability of the initial identification. The surveillance effort will be planned and conducted as was the initial collection effort.

Section III. PLANNING

119. General

When a contaminated area has been detected, the CBRE must begin the planning process necessary to expand the collection effort for collection of the information required to evaluate the contamination hazard. Proper planning of this collection effort is essential to producing timely radiological intelligence.

120. Estimate of the Situation

a. There will be portions of the area of interest in which the troop density will be sufficient to insure that automatic monitoring reports will provide adequate dose-rate information. Therefore, the first step of the planning process will be to analyze the area of interest on this basis and then to estimate what addi-

tional information, if any, will be required for evaluation of the hazard. Concurrent with this analysis and based upon operational requirements, an estimate must be made of the time within which the hazard must be identified. An illustration of this process is shown in the example of *b* below.

b. During a division offensive operation, a friendly weapon is detonated inadvertently at 0900 hours as a surface burst forward of the immediate division objectives. The fallout prediction indicates that the resulting contamination will lie across desired attack routes to objectives of the attack continuation and that fallout in this area will not be complete until 1100 hours. The chemical officer, after coordination with the G2 and G3, indicates that no aerial reconnaissance missions are planned over the area of interest and that the contamination hazard in the area of interest (desired attack route) must be evaluated by 1300 hours to allow the division staff adequate time for formulation of plans. Based upon this information, the following estimates can be made by the CBRE:

- (1) Little or no information from the automatic reporting system can be expected about the contamination until friendly troops come in contact with the hazard.
- (2) Required information about the contamination hazard on the desired attack route must be obtained and evaluated before 1300 hours.
- (3) As much information as possible about the remainder of the contamination hazard is desirable before 1300 hours but if necessary an effort to obtain this information can be delayed until the contaminated area has passed under control of the division.

121. Survey Planning

a. General. The radiological survey plan for a contaminated area will be based upon the estimation of many variables and must establish as a minimum the amount of detail required, method of control (decentralized or centralized), type of survey (ground or air), and the technique to be used (route, point, course leg, or preselected dose rate). The survey plan for a particular contaminated area will

probably contain a combination of these methods, types, and techniques. For example, a typical daylight survey of a contaminated area may include a centralized and a decentralized ground survey combined with a centralized aerial survey, where each covers a different zone within the contaminated area, and all the techniques may be employed.

b. Factors Affecting the Plan. Some of the many variables affecting the survey planning function, with guidance concerning their major effects, are listed below. In the preparation of the survey plan, each of these factors must be estimated and balanced against the need for information.

- (1) *Knowledge of the contamination.* Knowledge about the contaminated area which is available or expected to be available (such as fallout predictions and monitoring reports) will determine the size of the area to be surveyed and the amount of detail required.
- (2) *Operational situation.*
 - (a) In vague, fluid, or rapidly changing situations, centralized control may be necessary.
 - (b) Under the conditions in (a) above, aerial survey is desirable but ground survey may be required for critical routes such as main supply routes and counterattack routes.
 - (c) The operational situation will dictate the availability of personnel and equipment.
- (3) *Urgency.* Centralized aerial survey is normally the most rapid means of obtaining information.
- (4) *Weather.* Aerial survey may be precluded by poor visibility. Surveys should be delayed, if possible, during precipitation and high winds as these conditions tend to change a contamination pattern.
- (5) *Time of survey.* Nighttime aerial surveys will probably be of the hasty type and execution must be carefully planned. Detailed ground surveys normally can be accomplished at night or during the day.
- (6) *Terrain.* The road nets and the ability of the soil to support ground move-

ment may determine the use of ground survey. Aerial survey is of limited use in mountainous terrain. In areas (arctic, desert, jungle) where reference points are rare, marking may be required and the type of survey must be carefully selected.

- (7) *Status of training.* Inadequate training or losses of trained personnel may limit aerial survey capability. The status of training must be considered in selection of the type of survey. Status of training of control parties at subordinate headquarters will affect the method of survey (centralized or decentralized).
- (8) *Time-distance.* Time-distance factors must be estimated and considered when selecting the type of survey most appropriate to obtain and allow evaluation of required information within established time limits. Surveys in areas where fallout is not complete should be considered in relation to the established time limits for required information.
- (9) *Dose.* Dose status of survey personnel and the operation exposure guide set by the commander must be evaluated when planning the type of survey.
- (10) *Communications.* Availability of communications facilities will affect all phases of the survey plan. Centralized aerial survey normally will impose the least communications load.
- (11) *Maps.* The CBRE must consider the maps; and the areas they cover, available to units that will participate in the survey.

122. Special Reports Requirements

a. *General.* Based upon an estimate of the situation (par. 120) which includes the factors of paragraph 121, additional information required must be requested as special reports. Some of the requirements which may necessitate special reports are discussed in detail below.

b. *Points, Routes, or Areas of Operational Interest.* Some points, routes, or areas within a detected contamination hazard area may be of particular operational interest and thus may

require more urgent, detailed, or precise information than the remainder of the hazard area. Requirements for additional information in the contaminated area should be established by appropriate staff officers in coordination with the chemical officer. Special monitoring or survey missions may be necessary to satisfy these requirements. Examples of points, routes, or areas about which additional information might be required are ammunition or other vital supply points, main supply routes, proposed attack or counterattack routes, assembly areas, and critical observation posts.

c. *Dose-Rate Determination.* If an estimate of the situation in accordance with paragraph 120 indicates that available ground dose-rate information will be insufficient for required dose calculations, radiological survey or special monitoring reports will be required.

d. *Apparent H-Hour Determination.* In those cases where a detected radiological hazard cannot be related to a specific nuclear burst, special monitoring reports will be required to determine an apparent H-hour. Information necessary to determine the apparent H-hour is obtained from series of monitoring reports from several selected locations. When these series of monitoring reports are required, each dose rate must be taken with the radiacmeter placed at the same position within the selected location. Generally, each of these series should consist of at least 6 reports spaced over at least a 2½-hour period, followed by a series of hourly reports. The locations at which these series of readings should be taken are carefully selected by the CBRE, based upon the length of time a unit is likely to remain in its present location and the status of training of the unit. The locations should be selected so that the soil, vegetation, and other general features of the area are typical of the contaminated area. Further development of information depends upon the apparent H-hour determination; therefore, it is essential that these series of monitoring reports be properly and promptly accomplished with the information precisely determined.

e. *Decay-Rate Determination.* In all cases of detected contamination, the decay rate of the contamination must be determined for use in dose calculations. For induced contamination

hazards, the soil type, known or assumed, will determine the decay rate. For fallout from a known weapon where H-hour is known, the decay-rate determination can be made from the same type of reports as those required for the apparent H-hour determination (*d* above). For fallout from an unknown weapon where H-hour and decay rate are not known, decay-rate determinations will require either collection of actual contamination from the area for laboratory analysis or series of hourly monitoring reports from several locations within the contaminated area. These series of reports in this case should be at least 20 hours in duration and the locations should be selected as for apparent H-hour determination (*d* above).

123. Decentralized Survey

The CBRE may request that a subordinate unit be directed to conduct a survey. For example, division may direct a brigade to perform a survey of some sector or all of the

brigade area. The brigade control party plans and conducts the survey. This control party will plan the survey, brief and direct the survey parties, receive and check the data for completeness and reasonability, and transmit the data through proper channels to the division CBRE.

124. Survey Party Briefing

Adequate control of the radiological survey, once the survey plan has been initiated, will depend to a large extent upon proper briefing of the survey parties. Survey party briefings may vary from group to individual briefings, depending upon space, time, and operational conditions; briefings may be given in oral, written, overlay, or other form. In any case, a briefing should always be conducted. The written or oral briefing is essentially an order and should follow generally the form of the 5-paragraph operation order as shown in table VIII.

Table VIII. Radiological Survey Party Briefing Order

Reference list. List any maps, charts, or other documents necessary to understand the order.

1. SITUATION

a. Operational Situation. Briefly describe the operational situation as it concerns conduct of the survey, to include enemy forces, friendly forces, and planned actions.

b. Contamination Situation. Present any factual information available about the contaminated area, to include limits, dose rates, source of contamination, terrain, and weather.

2. MISSION

Clear, concise statement of task to be accomplished (who, what, when, where, and why).

3. EXECUTION

a. Concept of Operation.

b. Specific Assignment of Each Party. In subsequent separate lettered subparagraphs (such as *c*, *d*, *e*, below), give the specific task of each survey party. Include the coordination to be effected, if applicable.

c. Coordinating Instructions. The last subparagraph of paragraph 3 of the order contains instructions applicable to two or more of the survey parties, such as:

- (1) Time of departure and return.
- (2) Routes and alternate routes to and from the contaminated area.
- (3) Coordination to be effected.
- (4) Dose or dose rate danger limitations.
- (5) Actions to be taken upon reaching limitations in (4) above.
- (6) Time phasing for fallout.
- (7) Debriefing—where, when, by whom.

4. ADMINISTRATION AND LOGISTICS

Contains information such as required equipment and forms.

5. COMMAND AND SIGNAL

a. Signal.

- (1) Survey reporting procedure.
- (2) Call signs, times to report, and code.
- (3) Channels (primary and alternate).

b. Command. Location of control party.

Section IV. CALCULATION PROCEDURES

125. General

The calculations contained in this section represent the most detailed processing capability of the CBRE in its performance of the radiological functions. The extent to which these various information processing calculations will be used will depend to a considerable degree on the operational situation existing at the time a hazard is being evaluated (par.121b (2)) and upon the need for a detailed evaluation of the particular hazard.

126. Time of Completion of Fallout

An *estimate* of the time when all significant fallout will be completed at a particular location may be made by either of two methods, both of which are described below.

a. Mathematical Estimate. The time (T) by which fallout will be completed at any specified point is *approximately* one and one-quarter the time of arrival of fallout plus the time required for the nuclear cloud to pass over. This is expressed by the formula:

$$T_{\text{completion}} = 1.25 \times T_{\text{arrival}} + \frac{\text{cloud diameter}}{\text{effective wind speed}}$$

Determinations of time of arrival, cloud diameter, and effective wind speed are discussed in TM 3-210.

Example. For a particular location, the following data have been determined.

$$T_{\text{arrival}} = H + 2 \text{ hr.}$$

$$\text{Cloud diameter} = 4 \text{ km.}$$

$$\text{Effective wind speed} = 20 \text{ km/hr.}$$

$$T_{\text{completion}} = 1.25 \times 2 \text{ hr.} + \frac{4 \text{ km}}{20 \text{ km/hr}} \\ = 2.5 + .2 = 2.7 \text{ hr.}$$

Thus, at points where time of arrival of fallout is $H + 2$ hours, fallout should be completed by $H + 2.7$ hours.

b. Observation of Monitoring Data. The time of completion of fallout may be determined by noting the time at which monitoring readings for any one location reach a peak.

127. Determination of Decay Rate (H-Hour Known)

a. Kaufman Equation. Fallout, or any contamination comprised of a mixture of a large

number of isotopes, will decay according to the Kaufman equation:

$$R_1 T_1^n = R_2 T_2^n,$$

where:

R = dose rate at a location,

T = time in hours after H-hour,

n = decay constant, and

1 and 2 are subscripts denoting different times after H-hour.

When 1 denotes $H + 1$ and 2 denotes any other time, the equation becomes $R_2 = R_1 T_2^{-n}$.

b. Decay Rate. Dose calculations and pattern evaluations depend upon knowledge of the rate at which the contamination is decaying; thus, the decay constant must be known. In fallout contamination, the value of n will not necessarily be constant with time or even constant throughout a particular contaminated area although the pattern as a whole will have an average value. This average value will vary from pattern to pattern. The amount of variation is expected to be from about 0.8 to 2.0 for fallout; lower values of n can be expected for radiological agents or seeded weapons. The average value of n for most patterns will be 1.2, which is referred to as standard decay. Standard decay may be assumed when decay-rate estimation or determination cannot be made, but the decay rate for any fallout pattern should be assumed to be other than standard and a decay rate determined whenever possible.

c. Decay-Rate Determination or Estimation (H-Hour Known). The determination or estimation of decay rate depends upon knowledge of H-hour and may be accomplished graphically or mathematically as shown in *d* and *e* below. For either method, series of precise dose-rate readings from several selected locations are required (par. 122e). The reliability of the decay-rate calculation is directly related to the precision of the dose-rate readings, to the length of the time interval over which the readings were taken, and to the length of time over which dose calculations are to be made from the resulting pattern. That is, the more reliable the monitoring dose-rate readings and the longer the time interval over which they are taken, the longer the time period over which

reliable dose calculations can be made. As a rule of thumb for decay-rate determination, reliable dose calculations can be projected in time (T_p) over a period three times as long as the monitoring time interval. For example, for a decay rate determined from monitoring readings taken between $H + 1$ and $H + 4$, dose calculations could be reliably projected from $H + 4$ to $H + 13$ ($T_p = H + 4 + [3(4-1)] = H + 13$). An illustration of the way in which decay-rate determinations and estimations are used in developing a contamination pattern is given below.

Example. Consider a fallout-producing nuclear burst (H -hour known) with the collection effort initiated immediately and expected to be completed by $H + 3$; the target time for preparation of the pattern is $H + 5$. Here the decay rate is not known but is assumed to be standard for processing of dose-rate information taken

before $H + 2$. By $H + 2$ to $H + 2\frac{1}{2}$, a decay-rate estimation can be made and used to process the remainder of the dose-rate information from the collection effort. This procedure will result in a reliable $H + 1$ pattern. By $H + 4\frac{1}{2}$, a decay-rate determination can be accomplished which will allow use of the resulting pattern until about $H + 18$. By $H + 18$, a decay-rate determination can be accomplished which will allow use of the pattern until $H + 72$ hours.

d. Graphical Method for Determination of n . When a series of dose rates from one location is plotted on log-log graph paper, the decay rate of the contamination will cause the line plotted to be a straight line, inclined at a slope (n) to the axes of the graph.

Example. Suppose the set of readings shown below is received for decay-rate determination; H -hour is known or determined to be 0930 hours.

Time of reading	1000	1030	1100	1130	1200
Location	Dose rate (rad/hr)				
A	40	21	14	11	9
B		12	8	6	5
C			79	60	50

When these data are plotted on log-log graph paper, using the time as the number of hours past H -hour, and the best possible set of three lines is drawn through the points, the graph shown in figure 28 is obtained. The slope of these three parallel lines is n , the decay constant. A linear scale is superimposed on the graph as illustrated in figure 29 to show the determination of linear measurements. The value of n may then be determined for each location and an average n determined as shown below.

$$n_c = \frac{y_{c1} - y_{c2}}{x_{c1} - x_{c2}} = \frac{9.0 - 6.0}{9.2 - 5.9} = .91.$$

$$n_A = \frac{y_A}{x_A} = \frac{8.8}{9.6} = .92.$$

$$n_B = \frac{y_B}{x_B} = \frac{6.8}{7.6} = .90.$$

$$\text{Average } n = \frac{.91 + .92 + .90}{3} = \frac{2.73}{3} = .91.$$

e. Mathematical Method for Determination of n . The formula for the mathematical determination of the decay constant is found by solving the Kaufman equation (*a* above) for n .

Note. In all cases where " $\ln$ " is used, it is the symbol for natural logarithm.

$$\text{Thus, } n = \frac{\ln\left(\frac{R_1}{R_2}\right)}{\ln\left(\frac{T_2}{T_1}\right)}. \text{ Apply the monitoring data}$$

to this formula, using end point dose rates as shown below.

Location A.

$$n = \frac{\ln\left(\frac{40}{9}\right)}{\ln\left(\frac{2.5}{.5}\right)} = \frac{\ln(4.45)}{\ln(5)} = \frac{1.495}{1.608} = .930.$$

Location B.

$$n = \frac{\ln\left(\frac{12}{5}\right)}{\ln\left(\frac{2.5}{1}\right)} = .955.$$

Location C.

$$n = \frac{\ln\left(\frac{79}{50}\right)}{\ln\left(\frac{2.5}{1.5}\right)} = .946.$$

$$\text{Average } n = \frac{.930 + .955 + .946}{3} = \frac{2.831}{3} = .944 = .94.$$

128. Determination of Apparent H-Hour and True H-Hour

a. *Apparent H-Hour Determination.* The determination of an apparent H-hour is accomplished, using graphical and mathematical

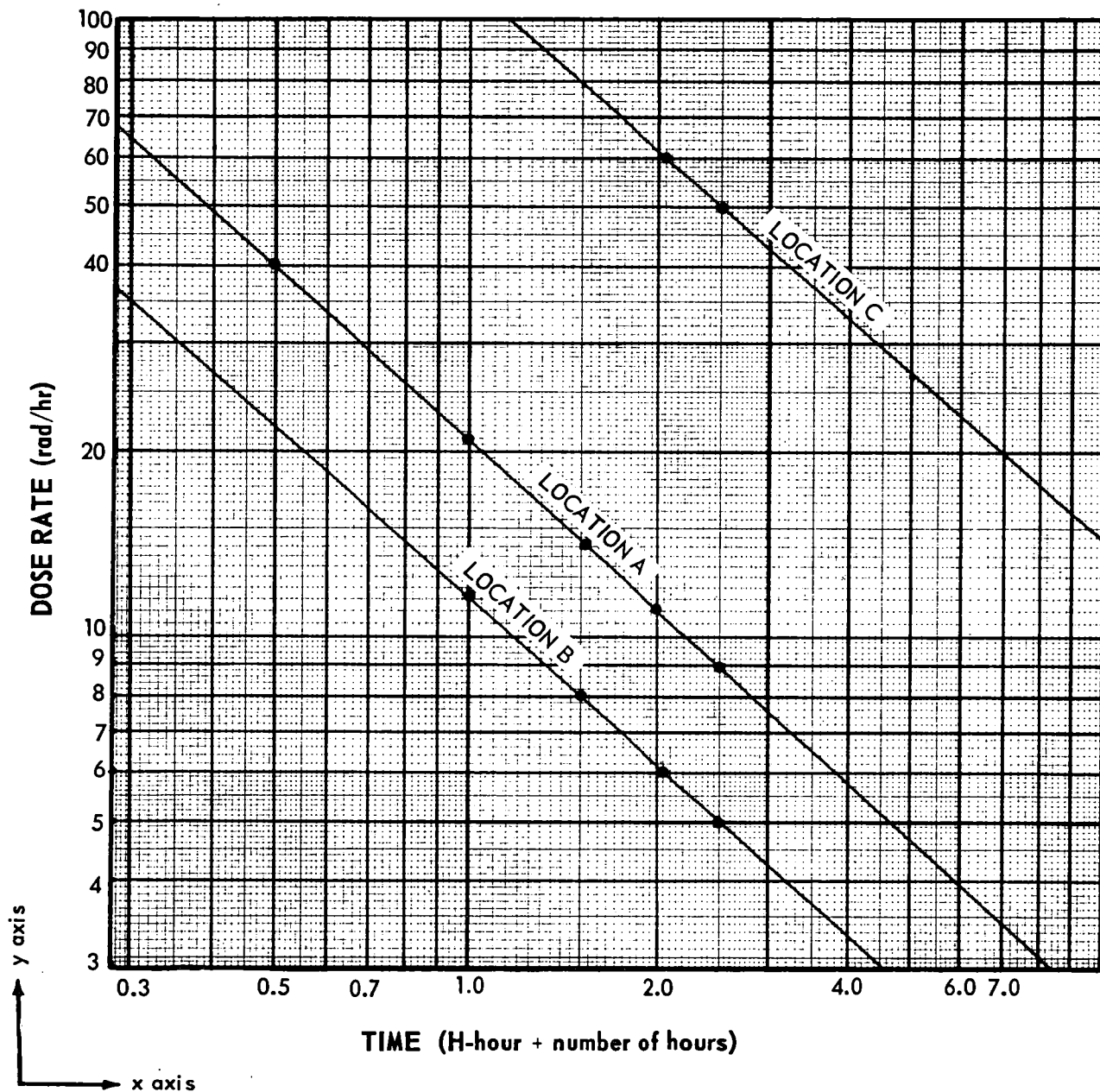


Figure 28. Decay-rate determination (monitoring reading plot).

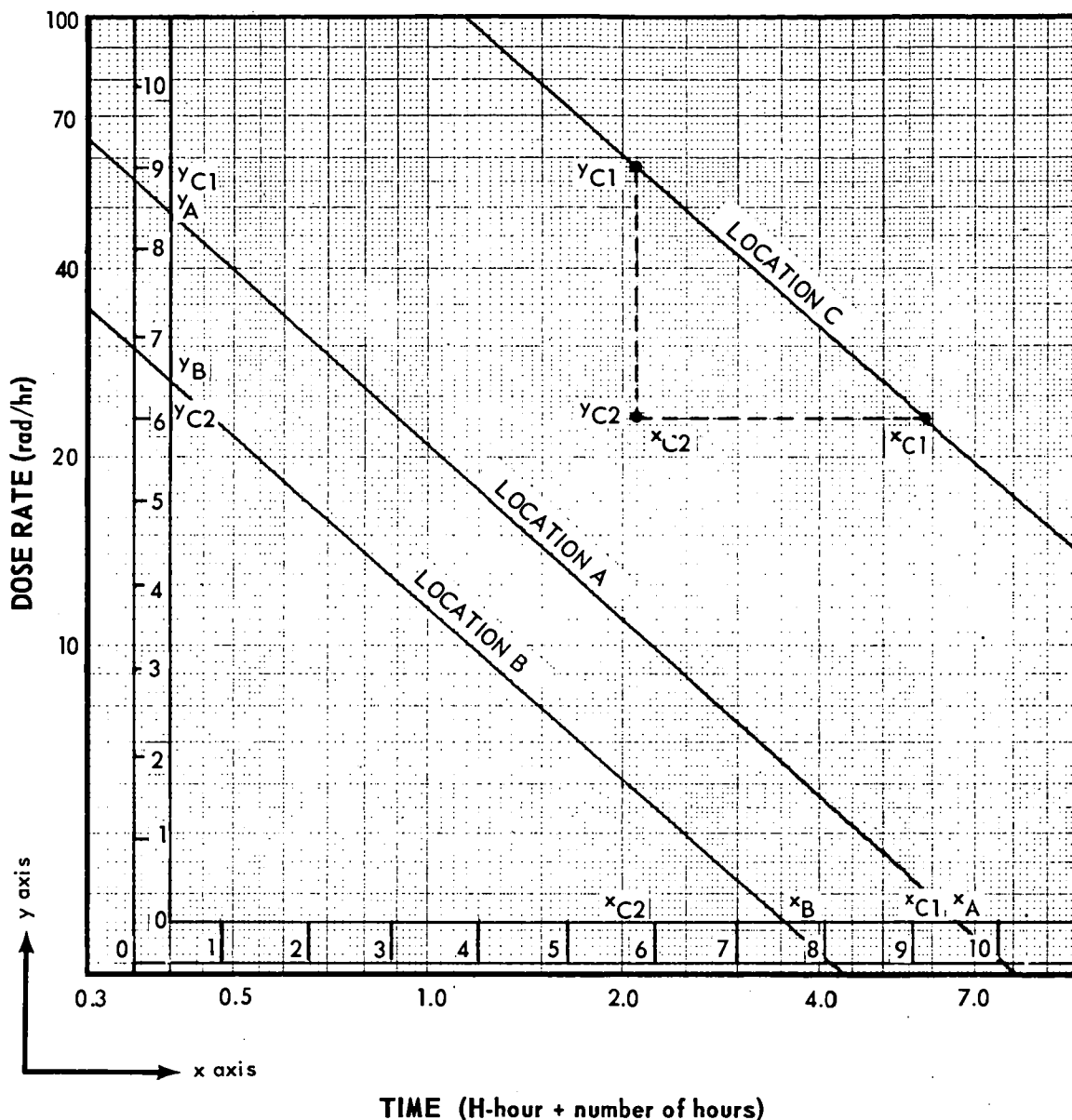


Figure 29. Decay-rate determination (measurement of slope).

approximations and all available information. The process is best explained by use of an example as shown below.

Example.

- (1) At 1200 hours, 10 January, a contaminated area is detected along the axis of advance of the 21st Division of the 1st Corps. By 1600 hours, the division has been stopped after advance elements of the division have overrun

the contaminated area. The division is preparing to continue the advance at 0500 hours, 11 January. At 1600 hours, 10 January, a collection effort was initiated which included a series of monitoring reports from each of three locations within the contaminated area.

- (2) By 1830 hours, monitoring has been completed, data are being processed as

of 1700 hours, and the following information is available for an apparent H-hour determination.

- (a) H-hour is known to be before 1000 hours.

- (b) The contamination is fallout.

- (c) The data from the monitoring reports which were received are shown below and are plotted as illustrated in figure 30.

Time of reading	1600	1630	1700	1730	1800	1830
Location	Dose rate (rad/hr)					
A	50	48	46	44	42	40
B	90	86	82	78	74	70
C	20	19	18	17	17	16

- (3) A quick estimation of H-hour as a function of the decay constant n can be made using the formula:

$$\text{H-hour} = \frac{T_a + T_b}{2} - \frac{\left(\frac{R_a + R_b}{2}\right)(T_b - T_a)n}{R_a - R_b},$$

where:

T = time in hours and tenths of hours on a 24-hour clock.

R = dose rate,

n = decay constant, and

a and b are subscripts denoting two different times at which dose rates are determined from the monitoring readings. For this case, $\frac{T_a + T_b}{2}$ is the average time at which the average dose rate, $\frac{R_a + R_b}{2}$, is determined by dose-rate readings R_a and R_b ; and $\frac{R_a - R_b}{T_b - T_a}$ is the rate of change of dose rate with time over the time period $(T_b - T_a)$.

- (4) These H-hour calculations are made for each location and an average H-hour is determined. If the monitoring information does not plot out as a straight line, calculations should be made for each half-hour interval.

Location A.

$$\begin{aligned} \text{H-hour} &= \frac{16.0 + 18.5}{2} - \frac{\left(\frac{50 + 40}{2}\right)(18.5 - 16.0)n}{50 - 40} \\ &= 17.25 - 11.25n. \end{aligned}$$

Location B.

$$\begin{aligned} \text{H-hour} &= \frac{16.0 + 18.5}{2} - \frac{\left(\frac{90 + 70}{2}\right)(18.5 - 16.0)n}{90 - 70} \\ &= 17.25 - 10n. \end{aligned}$$

Location C.

$$\begin{aligned} \text{H-hour} &= \frac{16.0 + 18.5}{2} - \frac{\left(\frac{20 + 16}{2}\right)(18.5 - 16.0)n}{20 - 16} \\ &= 17.25 - 11.25n. \end{aligned}$$

Average H-hour = 17.25 -

$$\left(\frac{32.5}{3}\right)n = 17.25 - 11.0n.$$

Thus, H-hour is estimated as a function of n .

- (5) The decay constant is assumed to be standard and an apparent H-hour is calculated to be:

$$\begin{aligned} \text{H-hour} &= 17.25 - 11.0 \times 1.2 = 17.25 - 13.20 = 0400 \text{ hours.} \end{aligned}$$

The 1700-hour pattern can now be normalized to $H + 1$ (0500 hours), standard decay can be assumed, and dose calculations can be expected to be valid until about 0200 hours, 11 January.

- (6) By 2400 hours, additional monitoring reports will be available which will allow a more precise determination of the apparent H-hour; the 1700-hour pattern will be normalized to the new reference time and calculations of dose will be valid up to 2400 hours, 11 January.

b. True H-Hour Determination. The true H-hour determination is accomplished, using mathematical procedures. This determination requires that the apparent H-hour and decay

constant be known and is illustrated by a continuation of the example of a above.

- (1) By 1200 hours, 11 January, the 21st Division had continued to advance and the contaminated area was now located in the 1st Corps area. 1st Corps CBRE had the following information available:
- (a) 21st Division CBRE had transferred available information on the area to 1st Corps.
 - (b) The latest apparent H-hour determination is $H\text{-hour} = 0200 - 20.0n$.
 - (c) Army had reported that the decay constant for the area was 1.0, as determined from samples of the contamination which had been forwarded to a chemical laboratory for analysis.

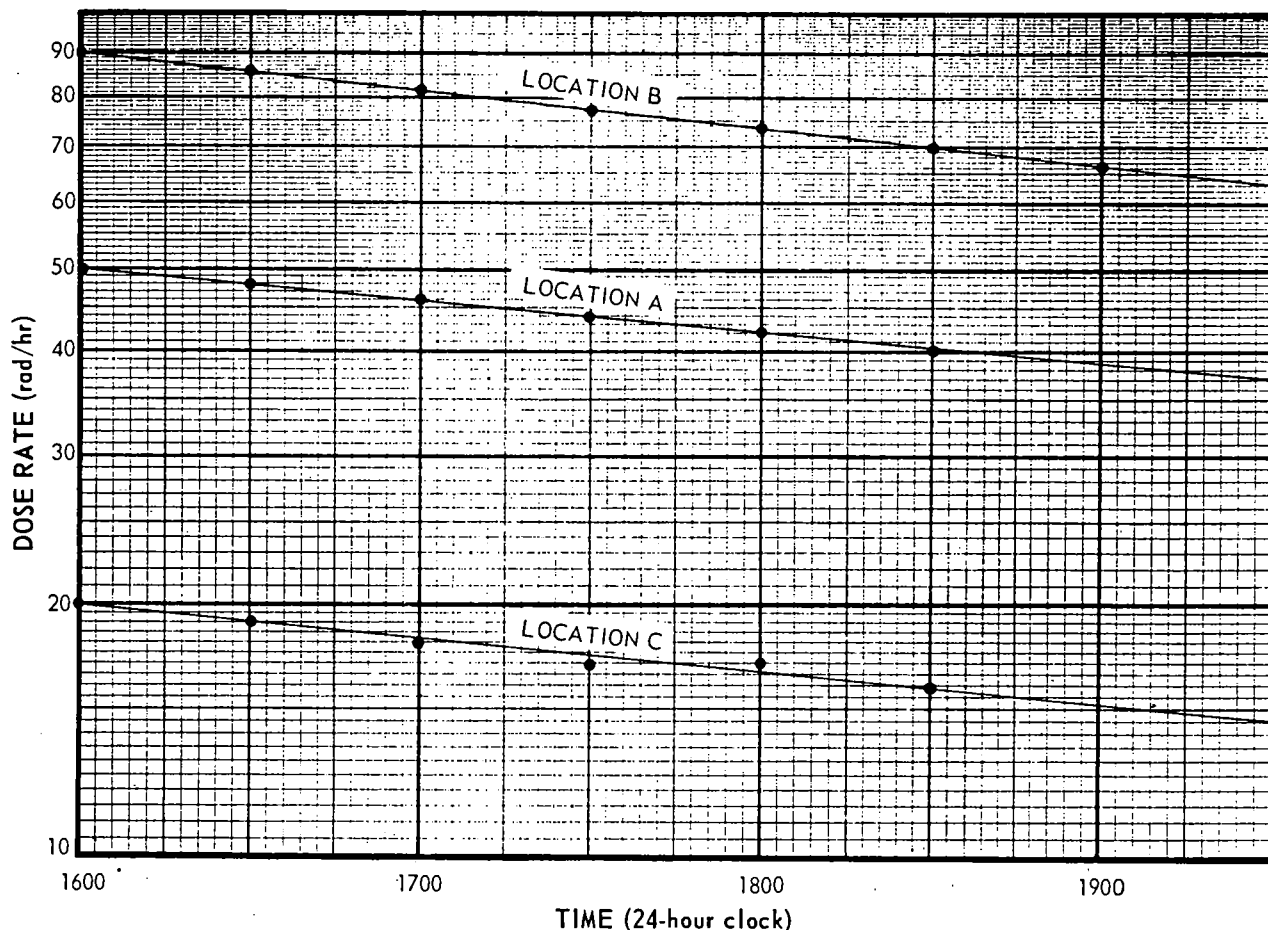


Figure 30. Apparent H-hour determination (monitoring readings).

(2) Thus,

$$\begin{aligned} \text{H-hour} &= 0200 - 20 \times 1.0 \\ &= 0200 - 20 \text{ hours} \\ &= 2400 - 1800 \\ &= 0600 \text{ hours, 10 January.} \end{aligned}$$

(3) The 1700-hour pattern can now be normalized to H + 1 (0700 hours), using a decay constant of 1.0, and the hazard will remain identified with a normal surveillance effort.

129. Determination of Decay Rate (H-Hour Unknown)

The determination of the decay rate in an area where H-hour is unknown is accomplished, using an apparent H-hour determination.

a. The determination of the decay rate of contamination in an area where H-hour is unknown is illustrated by continuing the example of paragraph 128 where laboratory facilities are not available for analysis of the contamination.

b. In this case, 1st Corps CBRE would have the following information available.

(1) Monitoring reports have been received up to 1200 hours, 11 January, and the following dose-rate information is available:

Time of reading	R_1 at 1600 (10 Jan)	R_2 at 1200 (11 Jan)	$\frac{R_1}{R_2}$
Location	Dose rate (rad/hr)		
A	50	16	3.125
B	90	30	3.000
C	20	7	2.857
Average	53.3	17.7	3.0

(2) The latest apparent H-hour determination is:

$$\text{H-hour} = 0200, 11 \text{ January} - 20n.$$

c. From the Kaufman equation:

$$\frac{R_1}{R_2} = \left(\frac{T_2}{T_1} \right)^n.$$

T_1 = time of the R_1 reading (referenced to apparent H-hour).

If the apparent H-hour is 0200, 11 January — $20n$ and time of R_1 reading is 1600, 10 January, then:

$$\begin{aligned} T_1 &= (0200, 11 \text{ January} - 20n) - 1600, 10 \text{ January} \\ &= 2600 - 20n - 1600 \\ &= 10 - 20n. \end{aligned}$$

Let T_2 = time of the R_2 reading (referenced to apparent H-hour).

The apparent H-hour is 0200, 11 January — $20n$ and time of the R_2 reading is 1200, 11 January, then:

$$\begin{aligned} T_2 &= (0200, 11 \text{ January} - 20n) - 1200, 11 \text{ January} \\ &= 0200 \text{ hrs} - 20n - 1200 \text{ hr} \\ &= -10 - 20n. \end{aligned}$$

$$\begin{aligned} \text{Then, } \frac{R_1}{R_2} &= \left(\frac{T_2}{T_1} \right)^n = \left(\frac{-10 - 20n}{10 - 20n} \right)^n \\ &= \left(\frac{20n + 10}{20n - 10} \right)^n. \end{aligned}$$

d. Calculate this equation for various values of n and equate against the average measured $\frac{R_1}{R_2}$:

1	2	3	4	5
n	$20n$	$\frac{20n + 10}{20n - 10}$	$\left(\frac{20n + 10}{20n - 10} \right)^n$	$\frac{R_1}{R_2}$
0.8	16	$26/6 = 4.33$	3.23	3.0
0.9	18	$28/8 = 3.50$	3.09	3.0
1.0	20	$30/10 = 3.00$	3.00	3.0
1.1	22	$32/12 = 2.67$	2.94	3.0
1.2	24	$34/14 = 2.43$	2.90	3.0

e. From this chart it can be seen that the calculated $\frac{R_1}{R_2}$ (col. 4) agrees with the measured $\frac{R_1}{R_2}$ (col. 5) when $n = 1.0$ and thus, n is determined to be 1.0.

130. Correlation Factor

Monitoring and survey dose-rate readings which are taken in a shielded position must be

converted to unshielded ground dose-rate readings. A multiplying factor used to accomplish this conversion is called a correlation factor. Note that the correlation factor is the inverse of the transmission factor and that space is provided on the radiological data sheets for both the required dose-rate information and the calculation of the correlation factor. If correlation factor data are not provided, but only the type of shielding is provided, transmission factors or correlation factors may be obtained from figure 18 or table II.

131. Normalizing Factor

The normalizing factor (NF) is the ratio of the ground dose rate at a reference time to the ground dose rate at any other known time, or

$$NF = \frac{\text{ground dose rate at a reference time}}{\text{ground dose rate at any other known time}}$$

Normalizing factors may be found mathematically or graphically, or may be taken from a table of values. Each method is described below.

a. Mathematical Method. The Kaufman equation, $\frac{R_1}{R_2} = \left(\frac{T_2}{T_1}\right)^n$, is used in determining the normalizing factor by the mathematical method, where subscript 1 denotes the reference time

and subscript 2 denotes any other known time at which a dose rate is determined.

Thus, since $NF = \frac{R_1}{R_2}$ and, since, $\frac{R_1}{R_2} = \left(\frac{T_2}{T_1}\right)^n$, it follows that $NF = \left(\frac{T_2}{T_1}\right)^n$. When the reference time is $H + 1$, $(T_1)^n = 1$ and $NF = (T_2)^n$.

b. Table of Values. Table IX is a table of normalizing factors for selected times after a nuclear burst and for various decay constants. The reference time in this table is $H + 1$. This table is normally used when H -hour is known for fallout contamination and the collection effort is initiated immediately.

Example. The collection effort has been initiated and H -hour has been determined to be 0800 hours. It is now 1130 hours and a dose-rate report of 150 rad/hr has been received from location A. What is the R_1 ($H + 1$) dose rate if the decay constant is 1.2?

Solution. From table IX, find the normalizing factor for a decay constant of 1.2 when the time after burst is 3 hours and 30 minutes.

$$\begin{aligned} NF &= \frac{R_1}{R_2} \\ \text{or, } R_1 &= NF \times R_2 \\ &= 4.5 \times 150 \text{ rad/hr} \\ &= 675 \text{ rad/hr.} \end{aligned}$$

Table IX. Normalizing Factors (correction to $H + 1$)

Time after burst	Decay constant (n)							
	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
10 min	0.340	0.238	0.167	0.116	0.080	0.056	0.040	0.027
20 min	0.520	0.419	0.333	0.268	0.214	0.171	0.138	0.120
30 min	0.660	0.579	0.500	0.437	0.377	0.330	0.286	0.250
40 min	0.785	0.727	0.667	0.613	0.564	0.520	0.400	0.440
50 min	0.900	0.870	0.833	0.805	0.775	0.750	0.718	0.690
1 hr 0 min	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1 hr 10 min	1.10	1.13	1.17	1.21	1.24	1.28	1.32	1.36
1 hr 20 min	1.19	1.26	1.33	1.42	1.49	1.58	1.67	1.77
1 hr 30 min	1.27	1.38	1.50	1.63	1.75	1.90	2.05	2.23
1 hr 40 min	1.36	1.50	1.67	1.84	2.03	2.25	2.50	2.76
1 hr 50 min	1.44	1.62	1.83	2.06	2.32	2.62	2.95	3.35
2 hr 0 min	1.52	1.74	2.00	2.30	2.61	3.00	3.43	3.96
2 hr 15 min	1.63	1.90	2.25	2.65	3.09	3.62	4.23	5.00
2 hr 30 min	1.73	2.07	2.50	3.00	3.58	4.30	5.12	6.18
2 hr 45 min	1.83	2.24	2.75	3.35	4.10	5.00	6.07	7.45
3 hr 0 min	1.93	2.40	3.00	3.73	4.62	5.72	7.10	8.90
3 hr 15 min	2.03	2.56	3.25	4.11	5.16	6.50	8.20	10.4

Table IX. Normalizing Factors (correction to $H + 1$)—Continued

Time after burst	Decay constant (λ)							
	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
3 hr 30 min	2.12	2.71	3.50	4.50	5.73	7.32	9.35	12.0
3 hr 45 min	2.21	2.86	3.75	4.90	6.35	8.20	10.6	13.8
4 hr 0 min	2.30	3.01	4.00	5.30	6.95	9.07	11.9	15.7
4 hr 20 min	2.41	3.21	4.33	5.81	7.73	10.3	13.8	18.6
4 hr 40 min	2.52	3.40	4.67	6.33	8.52	11.6	15.6	22
5 hr 0 min	2.63	3.60	5.00	6.88	9.40	12.9	17.8	25
5 hr 20 min	2.73	3.80	5.33	7.45	10.3	14.3	20	28
5 hr 40 min	2.84	4.00	5.67	8.03	11.3	15.8	22	32
6 hr 0 min	2.94	4.19	6.00	8.55	12.2	17.3	25	36
6 hr 20 min	3.03	4.38	6.33	9.10	13.2	18.8	27	40
6 hr 40 min	3.12	4.56	6.67	9.65	14.1	20	30	44
7 hr 0 min	3.21	4.73	7.00	10.2	15.1	22	33	49
7 hr 20 min	3.31	4.90	7.33	10.8	16.1	24	36	54
7 hr 40 min	3.40	5.00	7.67	11.4	17.1	26	39	59
8 hr 0 min	3.49	5.25	8.00	12.1	18.2	28	42	64

c. *Graphical Method.* The graphical method of determining the normalizing factor is based on the fact that a plot on log-log graph paper of normalizing factor versus the time at which a reading is taken is a straight line. The graphical determination of the normalizing factor is used when the time scope of table IX is too short or when normalizing to a time other than $H + 1$ is desired; for example, when H -hour and decay rate are initially unknown. Procedures for determining normalizing factors by the graphical method are shown by continuing the example in paragraph 128.

- (1) Shortly after 1700 hours of the example, the following monitoring reports are available.

Time of reading	1600	1630	1700
Location	Dose rate (rad/hr)		
A	48	47	45
B	90	85	80
C	20	20	17

H -hour or decay-rate estimations will not be available until after 1830 hours, but it is necessary to begin processing data from the collection effort so that the 1700-hour pattern will be available

as soon after 1830 hours as possible. By definition, the NF for readings taken at 1600 hours is:

$$NF_{1600} = \frac{\text{dose rate at 1700 hours}}{\text{(reference time) dose rate at 1600 hours}}$$

Thus, using the monitoring data, normalizing factors for 1600 hours and 1630 hours can be determined and averaged.

Average

$$\left. \begin{array}{l} \text{Location A} \\ NF_{1600} = \frac{45}{48} = .93 \end{array} \right\} NF_{1600} = .89$$

$$\left. \begin{array}{l} \text{Location B} \\ NF_{1600} = \frac{80}{90} = .89 \end{array} \right\}$$

$$\left. \begin{array}{l} \text{Location C} \\ NF_{1600} = \frac{17}{20} = .85 \end{array} \right\}$$

$$\left. \begin{array}{l} \text{Location A} \\ NF_{1630} = \frac{45}{47} = .96 \end{array} \right\} NF_{1630} = .92$$

$$\left. \begin{array}{l} \text{Location B} \\ NF_{1630} = \frac{80}{85} = .94 \end{array} \right\}$$

$$\left. \begin{array}{l} \text{Location C} \\ NF_{1630} = \frac{17}{20} = .85 \end{array} \right\}$$

$$\left. \begin{array}{l} \text{By definition,} \\ NF_{1700} = 1.0 \end{array} \right\} NF_{1700} = 1.0$$

If H-hour were known, these three normalizing factors could be plotted on log-log graph paper, a straight line could be projected through them, and any of the required normalizing factors could be determined. In this example, a rough apparent H-hour de-

termination, using the method of paragraph 128a is made and H-hour is estimated to be 0700 hours. Thus, 1700 hours is $H + 10$. Figure 31 shows the resulting normalizing factor plot for preparing the 1700-hour pattern. Using these normalizing factors, the

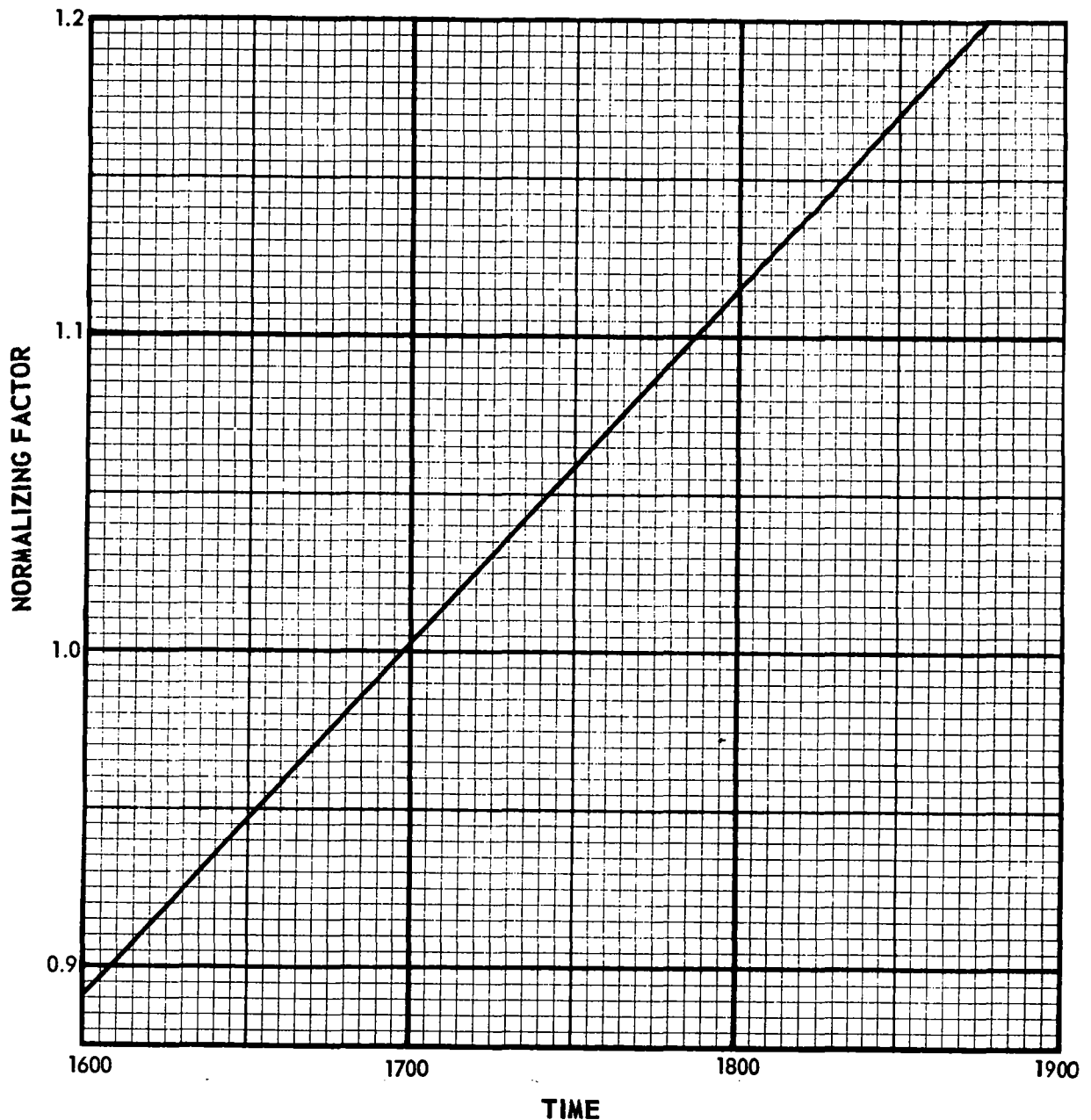


Figure 31. Normalizing factor determination (to 1700 hours).

1700-hour pattern developed will reliably depict the contamination situation as it existed at that time.

- (2) By 1845 hours of the example, the 1700-hour pattern should be completed and H -hour and n are estimated to be 0400 hours and 1.2 (par. 128a(5)). Normalizing factors are required to change the 1700-hour pattern to the $H + 1$ (0530 hours) pattern and to normalize any information from now until about 0030 hours at which time a more precise H -hour and decay-rate determination can be completed. The

normalizing factor at 0530 hours ($H + 1$) will be 1.0 and at 2400 hours is:

$$NF = T^n = 19.5^{+1.2} = 35.3 \text{ (2400 hours = } H + 19.5\text{)}.$$

As a check on the calculations, NF at $T = 10$ and $T = 13$ are calculated below:

$$NF = T^n = 10^{+1.2} = 15.8.$$

$$NF = 13^{+1.2} = 21.7$$

These four points are plotted on log-log graph paper through the period of interest, $H + 10$ to $H + 18$, as shown

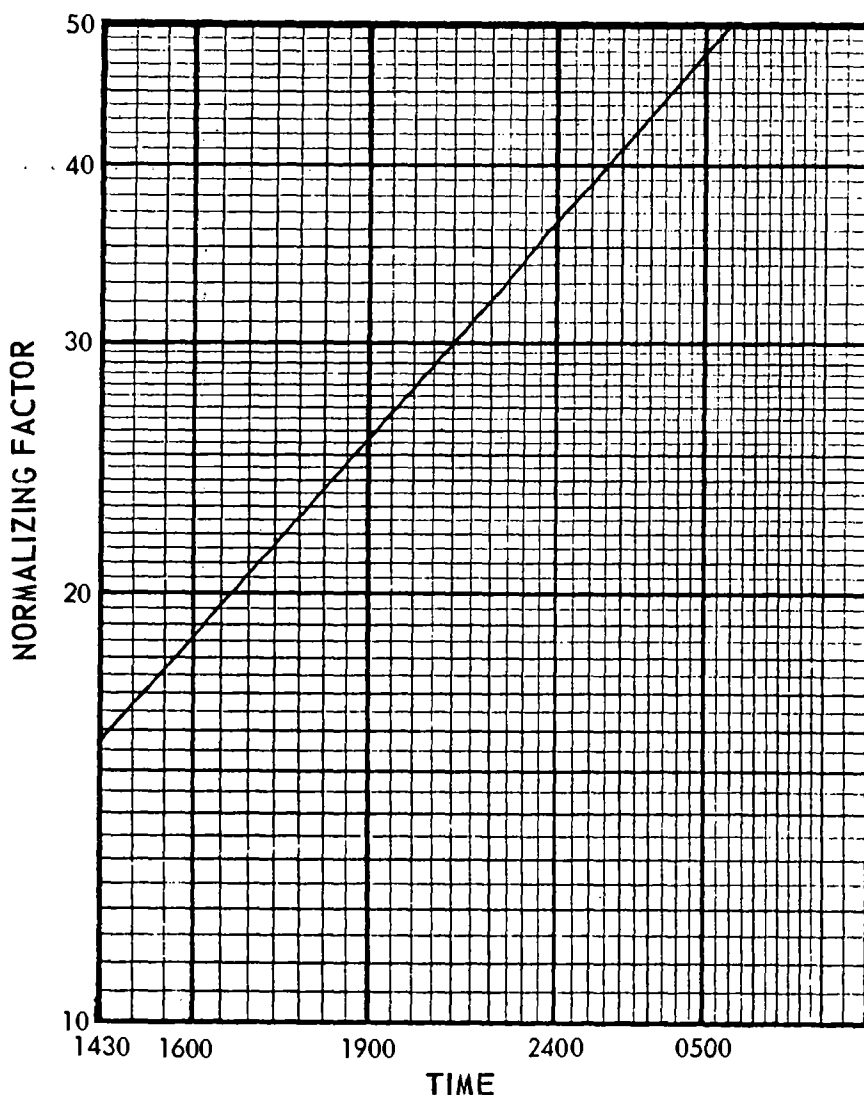


Figure 32. Normalizing factor determination (to 0530 hours).

in figure 32. The resulting graph provides required normalizing factors.

132. Overall Correction Factor

The overall correction factor (*OCF*) is the product of the correlation factor (*CF*) and the normalizing factor (*NF*). The calculation of

this factor greatly reduces the work required to calculate the final data to be plotted. Instead of multiplying each monitoring and survey reading by the *CF* and then the *NF*, each reading is multiplied by the *OCF* only. The overall correction factor is calculated as $OCF = CF \times NF$.

Section V. PLOTTING RADIOLOGICAL CONTAMINATION DATA

133. Plotting Requirements

The radiological situation map shows only the minimum essential information about detected and identified areas of contamination necessary to allow visual interpretation of the contamination situation. Each contaminated area is depicted on the map by a pattern of dose-rate contour lines and a few key dose rates for points, routes, or areas of particular concern. This information is developed by plotting monitoring and survey dose-rate information which has been corrected to unshielded ground dose rates at the reference time (normally $H + 1$) for the particular pattern. All monitoring and survey information for a contaminated area is eventually plotted as ground dose rates. These dose-rate plotting procedures are discussed in paragraphs 134 through 137. Plotting procedures to develop contour lines and key dose rates are established in paragraphs 138 through 140.

134. Worksheet Overlay

Determination of dose-rate contours and key dose-rate locations requires large quantities of dose-rate information. Once the contours and key dose rates have been determined, however, much of the dose-rate information would be extraneous on the radiological situation map. For this reason, worksheet overlays are prepared for the initial identification and surveillance of each contamination hazard and only the necessary identification data are transferred to the radiological situation map.

135. Single Point Dose Rates

Monitoring reports and ground and aerial survey reports from those parts of the survey accomplished using point techniques are directly processed and plotted into ground dose

rates at the points at which the readings were taken.

136. Route Techniques

a. *Ground Survey.* Dose-rate information from a ground survey accomplished using the route technique will be processed into normalized ground dose rates which existed at selected distance intervals along a route between two or more check points. The route, check points, and distance interval will be determined prior to the survey. The plotting procedure established in (1) and (2) below can be accomplished prior to receipt of the survey information.

- (1) Mark and label the check points on the worksheet overlay and trace out the preselected routes.
- (2) Divide the route between check points into the preselected distance intervals, moving in the same direction as that assigned the survey party.
- (3) Enter the normalized dose rate beside the proper location as processed data become available.

b. *Aerial Survey.* Dose-rate information from an aerial survey which was flown using the route technique will be processed into normalized ground dose rates which existed at certain points along the route. The method of plotting this information is shown in (1) through (3) below.

- (1) Before receiving the dose-rate information, mark and label the check points for the route on the worksheet overlay and trace out the preselected route.
- (2) After the survey data for the route are received, count the number of readings taken for the route. Care

must be taken to include all readings, including zero readings, since the number of time intervals used during flight of the route is required. Since the aircraft flew over the route at a constant ground speed taking readings at equal time intervals, the distance covered between any two consecutive

readings will be the same. Thus, if the route is divided into a number of equal length segments where the total number of segments is equal to the number of time intervals, each division point on the route will represent a location over which a dose-rate reading was taken. The number of time

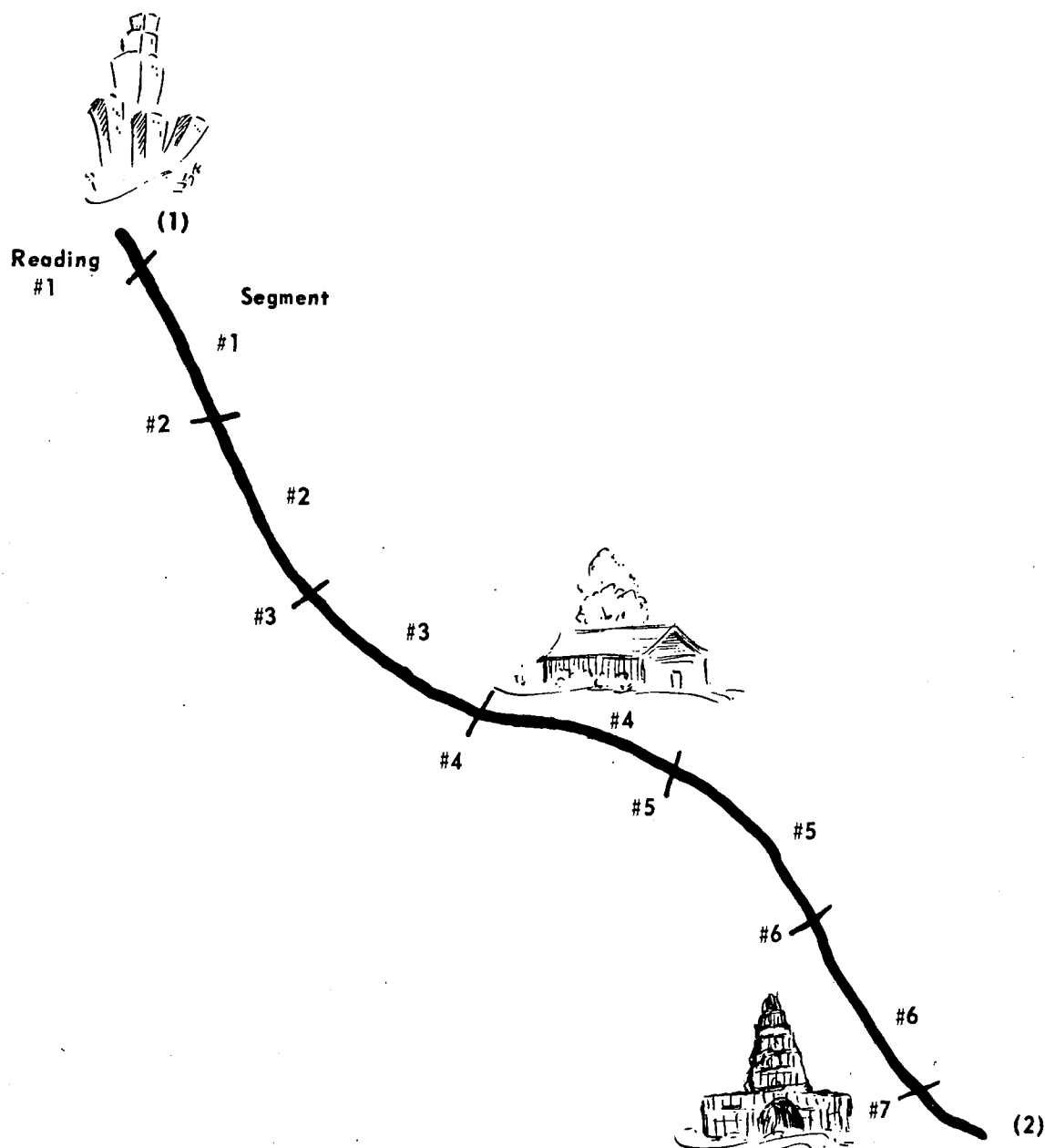


Figure 33. Plotting aerial survey (route technique).

intervals used (segments of the route) will be one less than the number of readings taken. For example, figure 33 shows the points along route (1) to (2) over which readings were taken. In this case, 7 readings were taken but the route is divided into only 6 ($6 = 7 - 1$) segments. Therefore, divide the route into a number of equal length segments equal to one less than the number of readings taken by the survey party.

- (3) Post the normalized dose rates on the worksheet overlay beside the location point for the route as the dose-rate readings are processed.

137. Aerial Survey Course Leg Technique

Dose-rate information from an aerial survey conducted by the course leg technique is plotted, using the same procedure as that established in paragraph 136b. The only difference between the two techniques is that in the route technique the survey party will proceed between two check points over a feature such as a road or railroad, whereas in the course leg technique the survey party will proceed on a straight line course between the two check points. The two check points are marked and labeled on the worksheet overlay and a straight line is drawn between them (par. 136b(1)). All other procedures are the same.

138. Contour Line Determination

Dose-rate contour lines depicting the contamination hazard in an area can be drawn when all the dose-rate information in the area is posted. This process is accomplished by—

- a. Determining the dose-rate contour lines to be plotted (for example, 10, 30, 100, 300, 1,000, 3,000 rad/hr).
- b. Determining the points along the various survey routes, course legs, and near monitoring locations where the desired dose rates are located; interpolate linearly between dose rates, if necessary.
- c. Connecting all the points having the same dose rates with a smooth line. Use all plotted

monitoring data as additional guides in constructing these contours.

139. Contour Line Plotting

a. The CBRE, upon receipt of survey data, plots the location, time of reading, and normalized dose rates on the radiological contamination overlay. Points of equal dose rates are connected to give a series of contour lines by interpolating between the plotted dose rates. The plotter must use care and judgment in plotting these contours and must visualize the probable general shape and direction of the pattern. In addition, he must carefully weigh dose-rate readings indicating possible hot spots. These will appear as dose rates disproportionately higher than other readings in the immediate area. When such readings are reported, a recheck in that area should be made; if confirmed, these hot spots should be plotted and indicated clearly.

b. The plotted contours may be extended or extrapolated to areas downwind in which fallout has not arrived and may be extended to intersect with ground zero if necessary to complete the fallout pattern. As more information is received, the pattern is altered accordingly and thus maintained up to date. Figure 34 shows a typical plot which might be developed from survey data.

140. Contour Drawing Considerations

In the construction of the radiological contamination overlay, proper consideration must be given to factors which locally affect the contamination pattern. This is particularly true between points in an aerial survey. These factors include, among others, presence of terrain features such as bluffs or cuts, heavily built-up or wooded areas, and bodies of water. For example, a large river will carry away the fallout which lands in it, leaving its path relatively free of contamination. Similarly, the contamination hazard near a lake will be lower than expected since the fallout particles will sink to the bottom and the water will provide shielding. In wooded areas or built-up areas, a measure of the reduction of dose rate can be obtained by using the transmission factors for these areas.

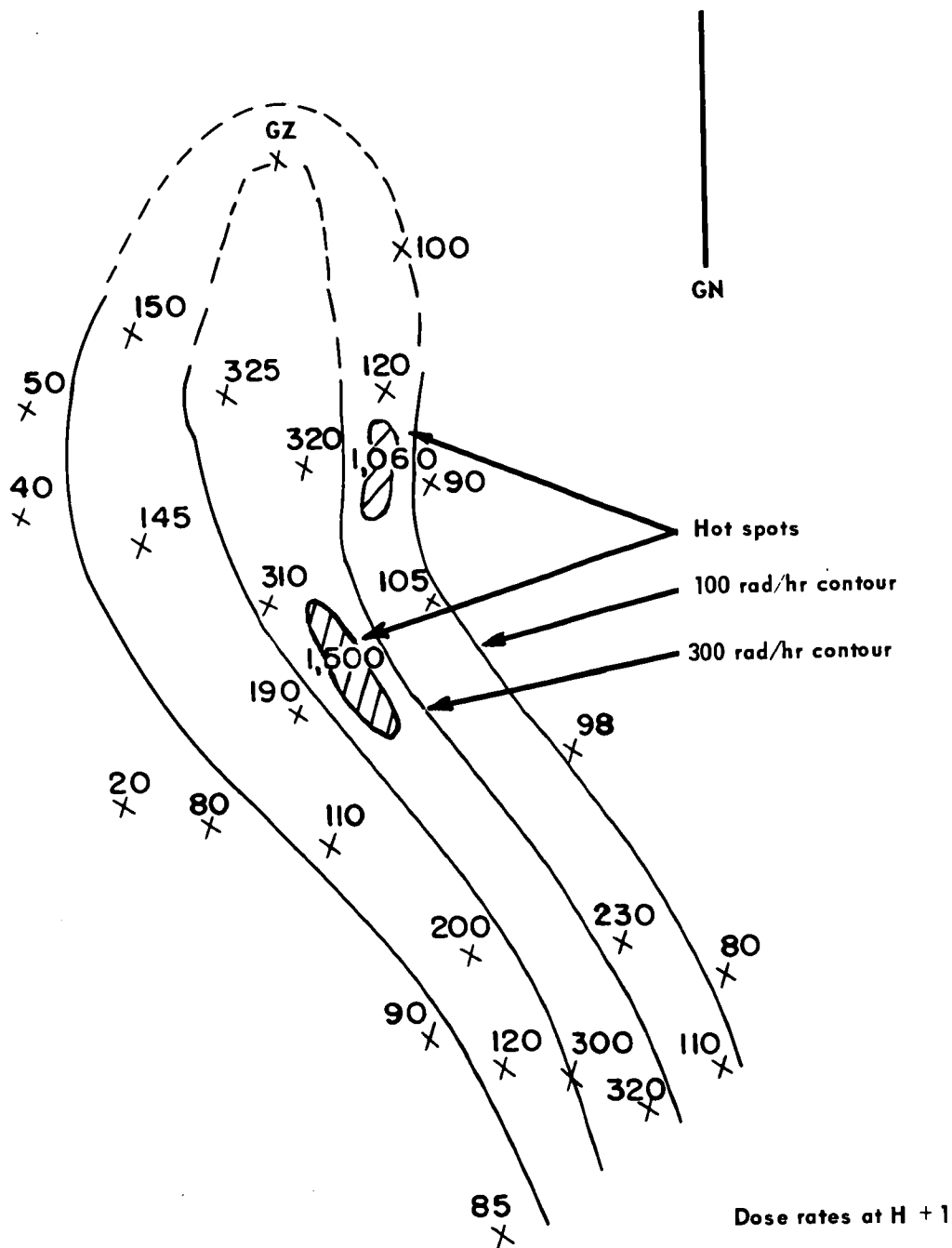


Figure 34. Fallout pattern plotted from survey data.

Section VI. PRESENTATION OF RADIOLOGICAL CONTAMINATION INTELLIGENCE

141. General

The purpose of preparing a radiological contamination overlay is to provide the commander and staff with a means of estimating or evaluating the effect of the radiological contamination hazard on current or future mission requirements. The format of the radiological contamination overlay is not prescribed but will depend on whether it is to be used for estimation or evaluation purposes. The following paragraphs illustrate some of the possible presentation formats.

142. Radiological Contamination Overlays (Evaluation)

Radiological contamination overlays to be used for evaluation purposes must provide the most detailed information.

a. The minimum information required is—

- (1) Map designation and orientation data.
- (2) Nuclear burst and ground zero identification.
- (3) H-hour.
- (4) Reference time.
- (5) Decay constant.
- (6) Time of preparation and validity.
- (7) Militarily significant contamination perimeter (10 rad/hr at $H + 1$).

(8) Dose-rate information (contour lines and key dose rates, if possible).

b. Additional information desirable but not essential is—

- (1) Time-of-completion lines for fallout.
- (2) Reference time doses for key crossings or probable stay times.

143. Radiological Contamination Overlays (Estimation)

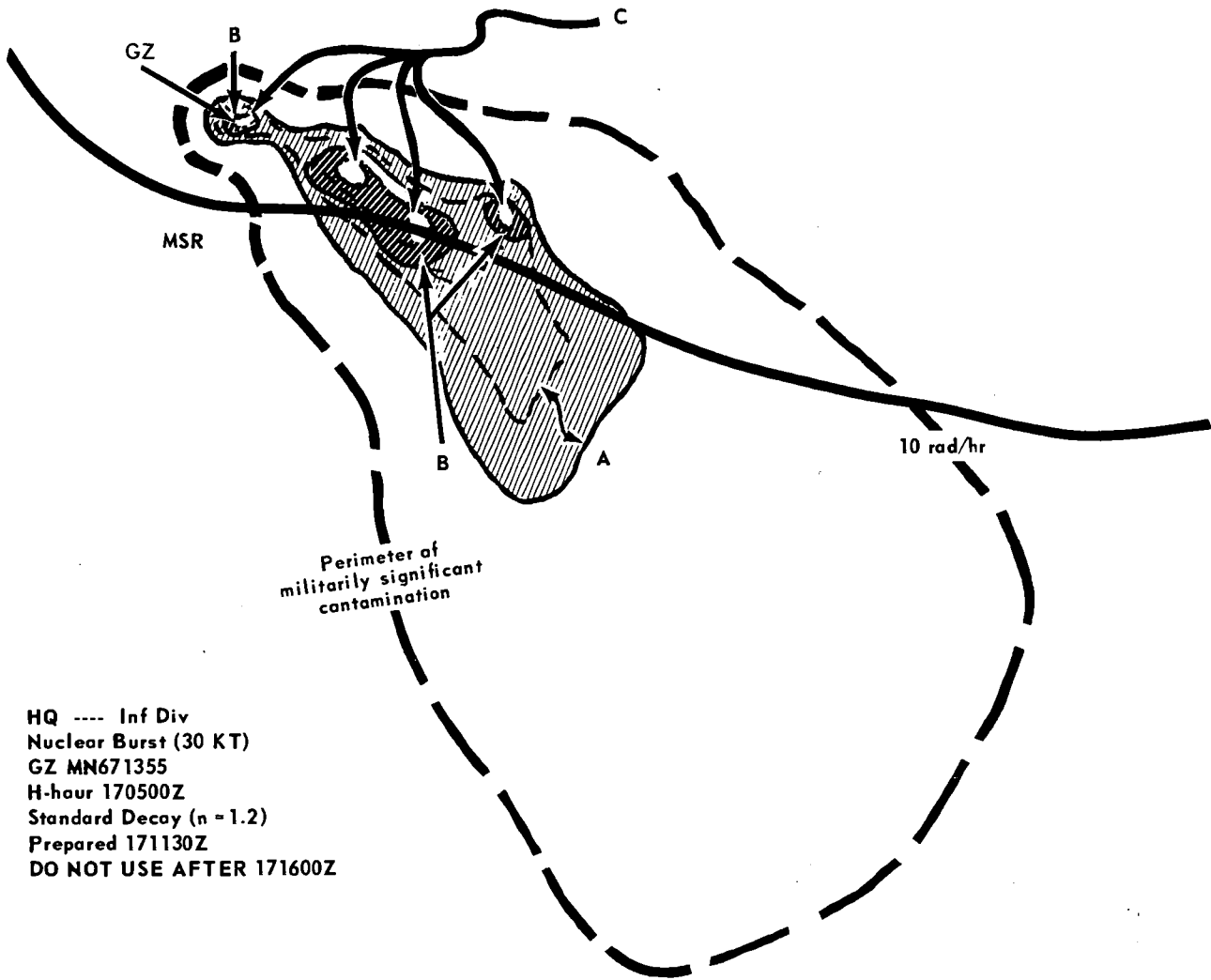
A radiological contamination overlay prepared for evaluation purposes does not lend itself to briefings and similar requirements. Here, a presentation of the current radiological contamination picture is required which will enable the viewer to visualize the current hazard and the decay of the hazard over a short (3- to 6-hour) period of time in the future. This form of intelligence is of particular use for the commander's briefing and for operation of CBRE's where detailed dose estimations are not required but where a quick visualization of the contamination hazard is essential.

a. An example of a contamination overlay prepared for estimation purposes, showing dose rates, is given in figure 35.

b. An example of a contamination overlay prepared for estimation purposes, showing dose areas for various times of stay, is given in figure 36.

MAP _____
SCALE _____

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HQ ---- Inf Div
Nuclear Burst (30 KT)
GZ MN671355
H-hour 170500Z
Standard Decay ($n = 1.2$)
Prepared 171130Z
DO NOT USE AFTER 171600Z

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- A 10 rad/hr at H + 7
....10 rad/hr at H + 11
- B 30 rad/hr at H + 7
....30 rad/hr at H + 11
- C 100 rad/hr at H + 7

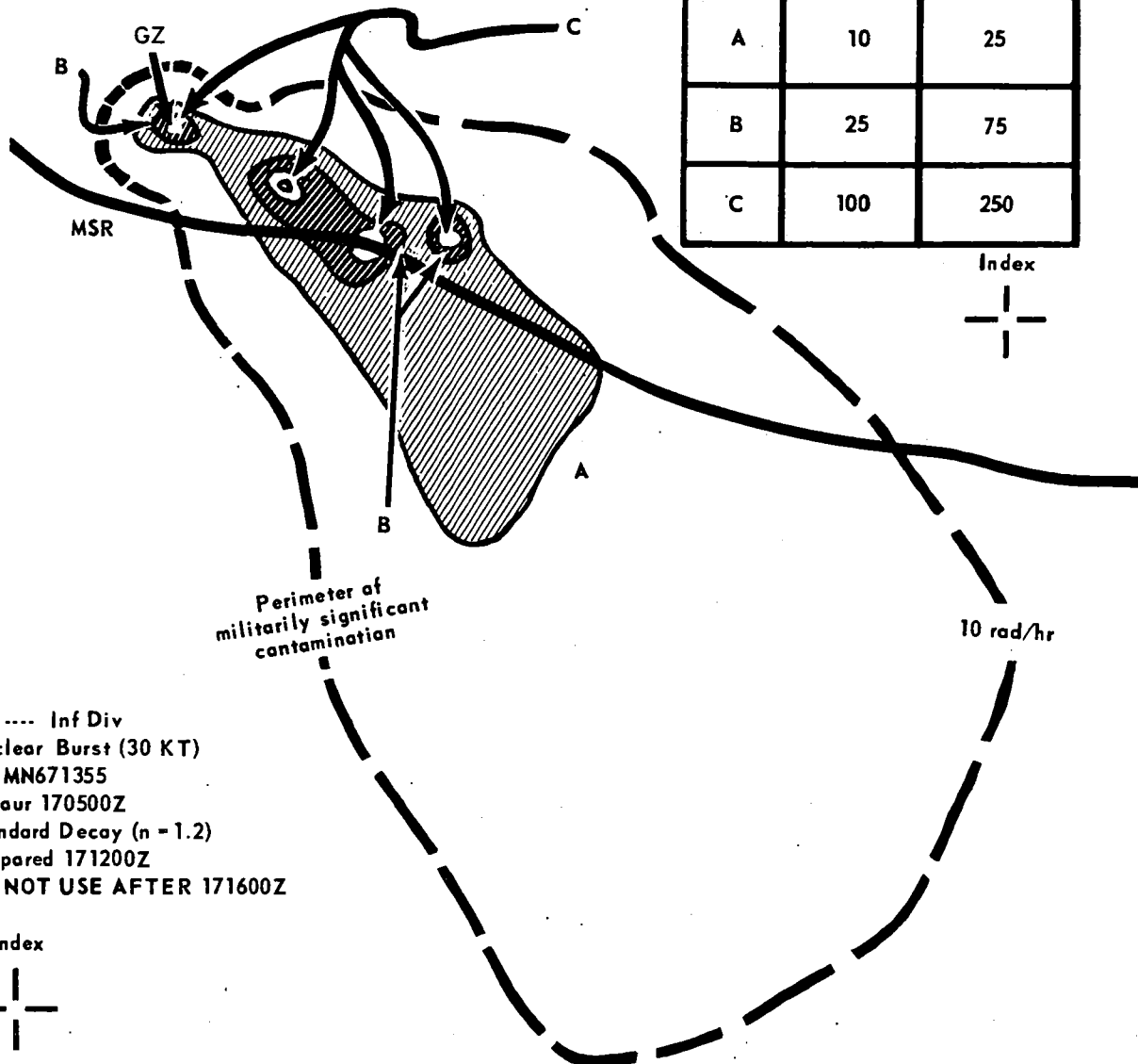
Figure 35. Current radiological contamination overlay (dose-rate type).

MAP _____
SCALE _____

ENTRY TIME AT H + 7

LOCA- TION	DOSE 1-hr stay (rad)	DOSE 4-hr stay (rad)
A	10	25
B	25	75
C	100	250

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HQ ---- Inf Div
Nuclear Burst (30 KT)
GZ MN671355
H-hour 170500Z
Standard Decay ($n = 1.2$)
Prepared 171200Z
DO NOT USE AFTER 171600Z

Figure 36. Current radiological contamination overlay (dose type).

APPENDIX I

REFERENCES

AR 320-5	Dictionary of United States Army Terms
AR 320-50	Authorized Abbreviations and Brevity Codes
AR 600-20	Army Command Policy and Procedure
FM 6-40	Field Artillery Cannon Gunnery
FM 21-26	Map Reading
FM 21-30	Military Symbols
FM 21-40	Small Unit Procedures in Nuclear, Biological, and Chemical Warfare
FM 21-41	Soldier's Handbook for Nuclear, Biological, and Chemical Warfare
FM 21-48	Chemical, Biological, and Nuclear Training Exercises and Integrated Training
FM 101-5	Staff Officers' Field Manual: Staff Organization and Procedure
(S) FM 101-31	Staff Officers' Field Manual: Nuclear Weapons Employment (U)
TM 3-210	Fallout Prediction
TM 11-6665-213-12	Operator and Organizational Maintenance Manual: Radiacmeter IM-174/PD
TC 101-2	Tactical Operations Centers
DA Pam 108-1	Index of Army Motion Pictures, Film Strips, Slides and Phono-Recordings
DA Pam 310-1	Index of Administrative Publications
DA Pam 310-3	Index of Training Publications
DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders
DA Pam 310-5	Index of Graphic Training Aids and Devices
DA Pam 310-7	Index of Tables of Organization and Equipment, Type Tables of Distribution, and Tables of Allowances
ASubjSed 3-18	Radiological Survey and Monitoring
TOE 3-500E	Chemical Service Organization
TF 3-3139	Nuclear Yield Estimation, Field Expedient Methods
TB CML 85	Calculator, Radiac, M1
TB CML 92	Calculator, Nuclear Yield, M28
STANAG 2103	Reporting Nuclear Detonations, Radioactive Fallout, and Biological and Chemical Attack

APPENDIX II

SAMPLE APPENDIX TO CBR ANNEX OF AN INFANTRY DIVISION SOP

Note. The following example of an appendix, for fallout prediction and radiological monitoring and survey, to the CBR annex of an infantry division SOP is furnished as a guide. Contents of the SOP and annexes vary with the mission, experience, and training of the unit. Separate appendixes to the CBR annex of the SOP may be required for such functions as personnel and equipment monitoring, decontamination, and other areas of radiological defense.

(Classification)

21st Inf Div
FORT McCLELLAN, ALABAMA
14 June 19----

ANNEX M CBR APPENDIX I (FALLOUT PREDICTION AND RADIOLOGICAL MONITORING AND SURVEY)

1. APPLICATION

Div SOP applies except as modified by division orders. Subordinate unit SOP's will conform. Attached units will comply with this SOP.

2. REFERENCES

FM 3-12, Operational Aspects of Radiological Defense.
TM 3-210, Fallout Prediction.
FM 101-5, Staff Officers' Field Manual: Staff Organization and Procedure.

3. ORGANIZATION

No change from current organization.

4. DUTIES AND RESPONSIBILITIES

a. Subordinate Headquarters.

- (1) Training. Subordinate headquarters will insure that individuals are trained and are available to fulfill their responsibilities for radiological monitoring, radiological survey, nuclear burst estimation, and fallout prediction as indicated in FM 3-12, Operational Aspects of Radiological Defense and TM 3-210. All aerial observers will be trained as aerial radiological survey monitors. All aviators will be trained to perform aerial survey duties. Assigned ground crewmembers of aviation units will be trained as aerial radiological survey monitors to provide an emergency capability.
- (2) Equipment. Radiological survey parties requested by division for centralized survey requirements will be equipped as specified in FM 3-12, Operational Aspects of Radiological Defense. Communications equipment required will be specified when a ground survey party is requested. Companies with available armored vehicles will equip ground radiological survey parties with armored vehicles. Companies providing aerial survey

(Classification)

monitors will supply a watch with sweep-second hand. All other equipment for the aerial radiological survey party will be provided by the aviation battalion. IM-93 dosimeters will be provided the aerial survey party whenever possible.

(3) Procedures.

- (a) General. Procedures for developing radiological contamination information are established in FM 3-12, Operational Aspects of Radiological Defense. Subordinate headquarters will establish monitoring and nuclear burst estimation procedures adequate to provide data for required reports. Monitoring is to be conducted from within shelter whenever possible.
- (b) Decentralized radiological survey. Battalion and larger units will be prepared to plan, control, and conduct ground and aerial radiological surveys as directed. Division will specify aircraft required and means of communication when aerial survey is ordered. Surveys initiated by subordinate headquarters will be coordinated with division headquarters.

b. Staff.

- (1) Staff responsibilities. These responsibilities are established in FM 101-5 and FM 3-12, Operational Aspects of Radiological Defense.
- (2) Dissemination. Lists will be maintained by the chemical officer for fallout prediction dissemination. Subordinate units and staff officers requiring fallout predictions will coordinate requirements as follows:
 - (a) Prestrike fallout prediction for friendly nuclear attack. Dissemination will be to FSE for incorporation in target analysis and as specified by G3.
 - (b) Poststrike fallout prediction for friendly nuclear attack. Dissemination will be as specified by G3.
 - (c) All fallout predictions for enemy nuclear attacks. Dissemination will be as specified by G2.
 - (d) Effective wind messages will be disseminated by the CBRE to all subordinate headquarters every 2 hours. (For format, see TM 3-210.) Subordinate headquarters that are not on the fallout prediction dissemination list but desire fallout predictions will use the effective wind message and the simplified fallout prediction method.
- (3) CBRE. CBRE responsibilities are established in TC 101-2. The radiological portion of the CBRE operations will be as established in chapter 8, FM 3-12, Operational Aspects of Radiological Defense.
- (4) Centralized radiological survey. Centralized radiological surveys will be planned, controlled, and coordinated by the CBRE in accordance with chapter 4, FM 3-12, Operational Aspects of Radiological Defense. Survey parties will be drawn from subordinate units.

5. RADIOLOGICAL CONTAMINATION WARNING

A warning will be broadcast over the division warning net whenever fallout occurs or new contamination is detected within the division area. This warning will be initiated by division (CBRE). Formats of fallout and contamination warnings are shown in tabs A and B.

6. REPORTS

a. Automatic Reports. Units will automatically submit those reports specified in FM 3-12, Operational Aspects of Radiological Defense.

b. Special Reports.

- (1) Summary reports. On direction of this headquarters, major subordinate units will submit a summary report showing the radiation situation in their assigned areas of responsibility. This report will normally consist of an overlay showing dose-rate contours as developed from monitoring reports and other sources.
- (2) Other special reports. Other special reports will be submitted as directed.

c. Survey Reports.

- (1) Centralized radiological survey reports will be submitted in accordance with chapter 4, FM 3-12, Operational Aspects of Radiological Defense. Specific communications facilities and procedures required will be established at the survey party briefing.
- (2) Data from decentralized surveys will be forwarded direct to the CBRE as obtained by the controlling agency. Such reports will be screened for adequacy of data but will not be otherwise processed or consolidated by subordinate headquarters.

d. Nuclear Burst Report Data. When a nuclear attack occurs, all units will make nuclear burst information observations, using methods established in FM 3-12, Operational Aspects of Radiological Defense. Information will be reported by the most rapid means available to this headquarters in the format described in FM 3-12, Operational Aspects of Radiological Defense.

e. Communications.

- (1) Precedence. Contact reports will be reported with EMERGENCY precedence by units in areas not predicted to receive fallout. All other reports will be of the highest precedence consistent with communications and operational requirements.
- (2) Channels. The area communications system will be the primary means used by brigade and separate units in reporting to division. Subordinate commanders will designate the communications means to be used within their commands to report monitoring, survey, and nuclear burst information. Units temporarily out of contact with an area communications center will use the division intelligence net as an alternate means.

ACKNOWLEDGE.

DISTRIBUTION: Same as SOP
OFFICIAL:

RELLUM
Maj Gen

1/s/Winfield
WINFIELD
G3

SAMPLE FALLOUT WARNING
FOR TRANSMISSION OVER DIVISION WARNING NET

RED DOG RED DOG—THIS IS VICTOR VICTOR BREAK

FALLOUT WARNING—FALLOUT WARNING

ZULU 240700

FOXTROT MN340670

GOLF 252292

HOTEL 1201803

AUTHENTICATION OF ---- IS ----

I SAY AGAIN

RED DOG RED DOG—THIS IS VICTOR VICTOR BREAK

FALLOUT WARNING—FALLOUT WARNING

ZULU 240700

FOXTROT MN340670

GOLF 252292

HOTEL 1201803

AUTHENTICATION OF ---- IS ----

OUT

Note. In this sample, RED DOG is the all station call for the division warning net; VICTOR is the division call sign; and ZULU, FOXTROT, GOLF, and HOTEL are the data lines of a fallout prediction message.

Tab A (Sample fallout warning for transmission over division warning net) to Appendix I to Annex M to 21st Infantry Division SOP.

SAMPLE RADIOLOGICAL CONTAMINATION WARNING (OTHER THAN FALLOUT)
FOR TRANSMISSION OVER DIVISION WARNING NET

RED DOG RED DOG—THIS IS VICTOR VICTOR BREAK

ROMEO WARNING FOR AREAS

MN2542BLUE MN2542GREEN MN2543BLUE MN2543GREEN

MN2442TOTAL AND MN2443TOTAL

AUTHENTICATION OF ____ IS ____

I SAY AGAIN

RED DOG RED DOG—THIS IS VICTOR VICTOR BREAK

ROMEO WARNING FOR AREAS

MN2542BLUE MN2542GREEN MN2543BLUE MN2543GREEN

MN2442TOTAL AND MN2443TOTAL

AUTHENTICATION OF ____ IS ____

OUT

Note. In this sample, call signs are as for the fallout warning of Tab A; ROMEO is a code word indicating radiological contamination other than fallout; and the letters and numbers designate 1,000-meter grid squares with the colors indicating a specific quarter of the grid square. Call signs and area codes are published in SOI.

Tab B (Sample radiological contamination warning, other than fallout, for transmission over division warning net) to Appendix I to Annex M to 21st Infantry Division SOP.

APPENDIX III SUMMARY OF FORMATS

Phonetic alphabet/ letter	TYPE OF REPORT				
	Fallout contamination plot message	Fallout prediction message	Effective wind message	NBC 4 monitoring report	NBC 1 nuclear burst report
ZULU/Z	DDtttt—date and time (GCT) of nuclear burst	DDtttt—date and time (GCT) of nuclear burst	DDtttt—date and time (GCT) at which the winds were measured		
ALFA/A	yyzzzzzz—grid coordinates yy—grid square des- ignation zzzzzz—coordinates	-----	dddss—for yield for 2 KT or less ddd—effective wind direction in degrees ss—effective wind speed in km/hr		
BRAVO/B	rrrr rrrr rrrr—dose rate contours	-----	dddss—for yields greater than 2 KT through 5 KT ddd—effective wind direction in degrees ss—effective wind speed in km/hr	-----	Position of Observer
CHARLIE/C	bbb cde cde cde—data for plotting contours bbb—azimuth in de- grees cde—distance in km and tenths of km from GZ for con- tours	-----	dddss—for yields greater than 5 KT through 30 KT ddd—effective wind direction in degrees ss—effective wind speed in km/hr	-----	Azimuth of Attack from Observer
DELTA/D	-----do-----	-----	dddss—for yields greater than 30 KT through 100 KT ddd—effective wind direction in degrees ss—effective wind speed in km/hr	-----	Date and Time of Attack (ZULU)

ECHO/E	do		ddsss—for yields greater than 100 KT through 300 KT ddd—effective wind direction in degrees ss—effective wind speed in km/hr		Illumination Time (seconds)
FOXTROT/F	do	yyzzzzzz—coordinates of ground zero			Location of Attack
GOLF/G	do	dddeccc—azimuth of left and right radial lines in degrees			
HOTEL/H	do	ssxxxrr—prediction dimensions ss—effective wind speed in km/hr xxx—downwind distance of Zone I in km rr—cloud radius of GZ circle in km			Type of Burst (air, surface, or unknown)
INDIA/I	do				Flash-to-Bang Time (seconds)
JULIET/J	do				
KILO/K	do				
LIMA/L	do				Nuclear Burst Cloud Width (mils or degrees)
MIKE/M	bbb cde rrrr—data for plotting hot spots bbb—azimuth from GZ cde—distance in km and tenths of km from GZ rrrr—dose rate of contour				Stabilized Cloud-top Angle and/or Stabilized Cloud-bottom Angle (mils or degrees). Report <i>Top</i> or <i>Bottom</i> with appropriate angle.)
NOVEMBER/N	do				
OSCAR/O	do				
PAPA/P	do				
QUEBEC/Q	do				
ROMEO/R	do				
SIERRA/S	do				
					Location of Reading Dose Rate (rad/hr) ¹ Date and Time of Reading

Phonetic alphabet/ letter	TYPE OF REPORT				
	Fallout contamination plot message	Fallout prediction message	Effective wind message	NBC 4 monitoring report	NBC 1 nuclear burst report
TANGO/T	bbb cde rrrr—data for plotting hot spots bbb—azimuth from GZ cde—distance in km and tenths of km from GZ rrrr—dose rate of contour				
UNIFORM/U	-----do-----				
VICTOR/V	-----do-----				
WHISKEY/W	-----do-----				
XRAY/X	-----do-----				
YANKEE/Y	rrrr bbbcde bbbcde—data for plotting hooked end rrrr—dose rate of hooked end bbb—azimuth in de- grees cde—distance in km and tenths of km from GZ				<i>References</i> Fallout contamination plot message—chapter 5 Fallout prediction mes- sage—TM 3-210 Effective wind message— TM 3-210 Monitoring report—chap- ter 3 Nuclear burst report— chapter 2

¹ Dose rates reported must be identified as contact, peak, shielded, or special. Report correlation factor information if shielded dose-rate readings are reported. Report in rad/hr.

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By Order of the Secretary of the Army:

EARLE G. WHEELER,
General, United States Army,
Chief of Staff.

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Units org under TOE:
17-22 (2)

NG: State AG (3); units—same as Active Army except allowance is one copy each unit.

USAR: Same as Active Army except allowance is one copy each unit.

For explanation of abbreviations used, see AR 320-50.

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FIELD MANUAL

OPERATIONAL ASPECTS OF RADIOLOGICAL DEFENSE

CHANGE }
No. 1 }

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., 19 March 1964

FM 3-12, 31 January 1963, is changed as follows:

Throughout manual, change "AN/PDR-27J radiacmeter" to radiacmeter IM-141/PDR-27J.

Throughout manual, change "rad per hour," "rd/hr" and "rad/rd" to rad/hr.

Throughout manual, change "M1 radiac calculator" to ABC-M1 radiac calculator.

Throughout manual, change "apparent H-hour" to calculated H-hour.

Change "H-23" to OH-23 in figure 11, page 39.

Make the following changes in table VI (page 78), date column "7":

Platoon A1, change 3 tickmarks to 2 tickmarks.

Platoon A2, change 4 tickmarks to 3 tickmarks.

4. Changes and Revisions (Superseded)

Recommended changes or comments to improve this manual should be forwarded direct to U. S. Army Combat Developments Command CBR Agency, Fort McClellan, Ala., on DA Form 1598 (Record of Comments on Publications).

7. Command and Staff Responsibilities for the Collection Effort

Except for the * * * adequate collection effort.

a. *Company/Battery Units.* Radiological monitors and * * * the collection effort. (A CBR team is a unit company/battery team appointed by the commanding officer. This team is made

up of TOE personnel with the CBR functions as an additional duty. The number of personnel on the team will be determined by the commanding officer and specified in the unit SOP. This team will have among its duties radiological monitoring and survey, chemical monitoring and survey, decontamination, unit CBR supply supervision, and CBR training of the unit. Decontamination operations may require additional personnel, dependent upon the size of the area and the quantity of materiel requiring decontamination.) Details of designating * * * unit CBR teams:

* * * * *

9. Use of the Types of Intelligence

As a type * * * is discussed below.

* * * * *

e. (Superseded) A history of all nuclear bursts that have occurred in the area may provide an indication of the types of nuclear weapons available in the enemy stockpile and the methods of delivery.

14. Transmission Factors

* * * * *

d. *Determination of Transmission Factors.* Transmission factors for common types of vehicles, structures, or fortifications are contained in figure 18. These transmission factors * * * in c above.

16. The Nuclear Burst Report

* * * * *

b. *Reporting.* The Nuclear, Biological, and Chemical (NBC) formats are devised for reporting nuclear, biological, and chemical attacks and follow STANAG 2103 (app. III). Although "r"

is used in STANAG 2103, TC 101-3 directs that "rad" be used within the Army for training and operational purposes. Therefore, "rad" or "rad/hr" is used throughout this manual. Only that portion * * * in this chapter. Nuclear burst data are reported to the CBRE by the most expeditious means available in the form of nuclear burst reports (NBC 1) as shown below.

Type of Report: NBC 1 (Nuclear).

- A. (Added) Strike Serial Number (if known).
- B. Position of Observer (UTM or place).
- C. (Superseded) Azimuth of Attack from Observer. [Report grid or magnetic (state which) bearing or azimuth of attack from observer (in degrees or mils, state which).]
* * * *
- K. (Added) Crater Present or Absent and Diameter, if Known. (Report in meters.)
* * * *
- M. (Superseded) Stabilized Cloud-top Angle and/or Cloud-bottom Angle or Cloud-top Height and/or Cloud-bottom Height. (Measure at H + 10 minutes; report in mils, degrees, meters, or feet; state which. Report Top or Bottom with appropriate angle.)
* * * *

d. *Example Nuclear Burst Reports.* The following are * * * by an observer.

Sample of First Nuclear Burst Report
(Superseded)

*Precedence
Date/Time (ZULU)
Security
From
To

NBC 1

B. ET 054066
C. Grid 182 mils
D. 090907Z
H. Surface
J. 23 seconds
L. 110 mils

*Heading as appropriate or as per unit SOP.

Sample of Second Nuclear Burst Report
(Superseded)

*Precedence
Date/Time (ZULU)
Security
From
To

NBC 1

B. ET 054066
D. 900907Z
M. 800 mils Top

e. *Responsibilities.* Collection of nuclear
* * * friendly or enemy.

* * * *

(2) *Enemy nuclear attack.*

(a) Units will submit a nuclear burst report as designated by SOP unless the burst is known to be friendly. Unit commanders should * * * should be designated.

(b) (Superseded) Reports on nuclear attacks are transmitted from the observing units to the division tactical operations center (CBRE), using the area communications system command, intelligence, or artillery channels as appropriate.

17. Sequence of Events

The most probable * * * are as follows:

a. *Daytime Burst.*

* * * *

(3) Complete lines B, D, and H and submit first nuclear burst report (NBC 1).

* * * *

19. Nuclear Burst Information

a. *Requirements.*

(1) *Estimates of the situation.* The essential nuclear burst information required for estimates of the situation is location of ground zero (GZ), total yield, time of burst, and type of burst.

* * * *

25. Nuclear Burst Parameters for Yield Estimation

c. Stabilized Cloud-Top Angle or Cloud-Bottom Angle.

- (3) For example, an * * * bottom) of the yield scale. Either the M4 nuclear yield calculator or figures 6 and 7 may be used for yield estimation. The slight variation between the M4 calculator and the figures is considered insignificant. It is emphasized that all these yield calculations are field estimates. The parameters are derived by human estimation and are therefore subject to variations; however, the yield estimations are considered acceptable for field use.

26. Illumination Time

- b. (Superseded) The data below show rough estimations of yield, using illumination time:

Illumination time (seconds)	Yield (KT)
less than 1	1 to 2
1	2.5
2	10
3	22
4	40
5	60
6	90
7	125
8	160
9	200
10	250
12	325
14	475
16	700

Note. Estimations of yield using illumination time may be obtained by using the M4 nuclear yield calculator.

27. Nuclear Yield Calculator

- c. Use. Calculations are made * * * on the back. For detailed example problems, see TB CML 92.

32. Types of Monitoring

- b. Continuous Monitoring. Continuous monitoring is * * * the following situations:

- (7) When radiation above * * * by periodic

monitoring. Units will discontinue continuous monitoring on orders from higher headquarters or when the dose rate falls below 1 rad/hr (except for units on the move).

33. Monitoring Techniques

Monitoring techniques vary * * * in paragraph 43.

- a. Direct Technique. The direct determination * * * the monitoring techniques. The unshielded ground (outside) dose rate may be determined directly by standing at the desired location, holding an area survey meter waist high, in a vertical position (face horizontal), and observing the dose-rate reading. The preferred procedure * * * moving on foot.

39. Format for Monitoring Reports

- a. Format. The format for monitoring reports follows the format established in STANAG 2103 (app. III). Only that portion * * * monitoring reports follows:

S. Date and time of the reading in Greenwich Civil Time (ZULU).

Note. Letter items Q * * * often as necessary.

40. Automatic Reports

Proper functioning of * * * areas of responsibility.

- a. Contact Report. Warning units of * * * the following conditions:

- (1) Contact reports will be submitted with IMMEDIATE precedence whenever an initial ground dose rate of 1 rad/hr or more is detected in an area not predicted to receive fallout. These reports will * * * detected and reported.

44. General

- a. Radiacmeters for Monitoring Personnel, Food, Water, and Equipment. The standard Army radiacmeter, IM-141/PDR-27J, is used in monitoring personnel, food, water, and equipment. It is equipped with a separate probe and

earphones to facilitate monitoring. The monitor can *** contamination is encountered.

* * * * *

50. General

Radiological survey is * * * on the ground. A radiological survey is performed by a group comprised of a control party and one or more survey parties. The control party * * * and security personnel.

52. Survey Control Methods (Superseded)

The primary method of survey control is a centralized operation in which the authority ordering the survey provides the control party and the radiological data is reported direct to the control party. For example, if division orders an aerial survey, the CBRE will act as the control party. Data are not screened, consolidated, or evaluated at intermediate headquarters. The alternate method of control is a decentralized operation directed through command channels and controlled by a subordinate command which furnishes the radiological data to the authority ordering the survey.

53. Radiation Safety

An operation exposure * * * ordered the survey. The survey party is notified of the operation exposure guide for the survey.

55. Coordination

Wherever practicable, the control party will coordinate the activities of the survey parties with the units located in the area to be surveyed. If coordination by the control party is impractical due to communications failure or other cause, the survey parties will be informed that coordination has not been effected. The survey parties will be directed to effect coordination provided the situation in the area and the required time of completion of the survey permit.

56. General

Radiological contamination information can be obtained by use of the radiacmeter IM-174/PD, held in a vertical position (face horizontal),

Table I. (Superseded) Location of Survey Meter During Aerial Survey

Aircraft ¹	Survey meter location
OH-13	Held directly behind right cyclic stick or in front of the right seat.
OH-23	Held in front of left seat between the cyclic stick and the antitorque pedals.
UH-1	In the passenger compartment, held in front of the second seat from the left side of the aircraft.
UH-19	In the passenger compartment, held in front of the seat at station 136.
CH-21	In the passenger compartment, held in front of the seat at station 299.
O-1A	Held in front of the rear seat at station 61.
U-6A	Held in front of right rear seat. ²

¹ Order of preference of currently available aircraft for use in aerial survey is as listed.

² Air-ground correlation factor data are obtained with the instrument at this location, assuming that the fuel tank under this location is full and that no auxiliary fuel tanks are located between the meter and the contaminated area. If the fuel tank is not full, if it is in use while surveying, or if auxiliary fuel tanks interfere, the air-ground correlation factor data are not reliable.

in rotary-wing or fixed-wing aircraft. Since aerial surveys * * * personnel, and communications.

60. Air-Ground Correlation Factors

An air-ground correlation * * * air-ground correlation factor.

* * * *

b. When tactical considerations * * * reading was taken. For example, while flying at a 500-foot altitude in an UH-1, a reading of 10 rad/hr is obtained; the air-ground correlation factor for an UH-1 at a height of 500 feet is 8.2.

$$\begin{aligned}
 &\text{Ground dose rate} \\
 &= \text{Aerial dose rate} \times \text{AGCF} \\
 &= 10 \text{ rad/hr} \times 8.2 \\
 &= 82 \text{ rad/hr.}
 \end{aligned}$$

62. Recording and Reporting

a. *Recording.* The radiological data * * * overall correction factor. A completed radiological data sheet, showing data collected by use of the course leg technique during aerial survey and CBRE calculations, is illustrated in figure 11.

* * * *

Table II. (Superseded) Air-ground Correlation Factors (AGCF)

Height above ground		Aircraft					
(meters)	(feet)	OH-13 or UH-1	UH-19	CH-21	OH-23	O-1A	U-6A
30	100	2.2	2.4	2.6	2.2	2.2	4.1
60	200	3.2	3.6	3.8	3.4	3.3	6.2
90	300	4.5	5.0	5.4	4.7	4.6	8.7
120	400	6.2	7.0	7.4	6.5	6.3	12
150	500	8.2	9.1	9.7	8.5	8.3	16
300	1,000	29	32	35	30	29	55
600	2,000	300	340	360	310	310	580
900	3,000	2,600	2,900	3,100	2,700	2,600	4,900

Note 1. The use of the AGCF with readings taken at these heights results in only an approximation of ground dose rates.

Note 2. The figures given above have been rounded off to two significant figures for practical use.

64. Reliability

With the guidance * * * sufficiently reliable data. Generally, the dose rate determined by aerial survey, for a particular ground location, varies from the true dose rate at the ground location because of survey meter errors, pilot errors, monitoring errors, errors due to contamination of aircraft at touchdown for ground reading, and the overall system errors.

65. General

Radiological information can be obtained by use of the IM-174/PD, held in a vertical position (face horizontal), by personnel mounted in wheeled or tracked vehicles. The information can * * * personnel and equipment.

68. Planning

The plan for * * * the survey party.

b. For planning purposes, or when the situation does not permit the use of the preferred method as described in *a* above, published correlation factors (fig. 18) may be used by the control party for calculating ground dose rates. The location of the survey meter when published correlation factors are used will depend upon the vehicle in which the survey meter is operated (par. 69b).

69. Survey Meter Location in Vehicles

a. Most dose-rate readings * * * ground dose rates. The position of the survey meter should

be as far from the sides, top, and floor of the vehicle as practicable (fig. 12). The monitor should * * * the selected position.

b. (Superseded) When correlation factor data cannot be obtained by the survey party, published correlation factors may be used from figure 18.

Figure 13. Survey meter location (tank).

Rescinded

75. Equipment Requirements for Survey Parties

e. *Transportation.* Vehicles with high * * * for ground surveys. Aircraft should be selected in accordance with the preference order criteria of table I for aerial surveys.

76. General

(Superseded)

Operations in a nuclear environment will require frequent exchange of fallout contamination information. Since duplication facilities and distribution means are limited in the field, transmission and exchange of fallout contamination overlays must be accomplished by use of existing communications facilities. Normally, reports of areas of contamination are disseminated as NBC 5 (nuclear) reports as prescribed in STANAG 2103 (app. III). When rapid distribution means are available, the fallout contamination overlay should be used if time permits preparation and duplication. This overlay will give the recipient a detailed, accurate picture of the fallout contamination situation for a particular area of interest.



Figure 12. (Superseded) Survey meter location (1/4-ton truck).

77. Fallout Contamination Plot Message Rescinded

Figure 14. Fallout contamination plotter.
Rescinded

78. Plotting Data From Fallout Contamination Plot Message Rescinded

Figure 15. Example problem, fallout contamination plot.
Rescinded

Table III. Sample fallout contamination plot message.
Rescinded

80. Decay Calculations

* * *

d. *Example problems.* In working with * * * example problem 4. In the case of greater values, divide the dose rate by 10, proceed with the calculation, and multiply the resulting dose

rate by 10. When using this * * * the dose-rate values.

* * *

(4) *Example problem 4.*

* * *

SOLUTION. Connect 2,000 rad/hr * * * R_t scale. Divide this dose rate by 10 since the R_1 value was multiplied by 10; then, the dose rate at $H + 25$ hours is 4.4 rad/hr.

85. Radiac Calculator

* * *

c. *Use Problems* involving decay, normalizing, dose, dose rate, time of stay, and time of exit can be solved with the ABC-M1 calculator. For example problems, see TB CML 92. In the descriptions * * * procedures are reversible.

* * *

Environment shielding	Transmission factor	Correlation factor
VEHICLES		
<u>Armored</u>		
Carrier	0.6	1.7
Tanks		
Light	0.2	5
Medium or heavy	0.1	10
<u>Trucks</u>		
1/4-ton	0.8	1.3
3/4-ton	0.7	1.4
2 1/2-ton	0.6	1.7
4-ton to 7-ton	0.5	2
STRUCTURES		
<u>Multistory buildings</u>		
Top floor	0.1	10
Intermediate floor	0.02	50
Lower floor	0.1	10
Basement	0.01	100
<u>Frame house</u>		
First floor	0.5	2
Basement	0.1	10
URBAN AREA (in open)	0.7*	1.4
WOODS	0.8*	1.3
SHELTER, CLOSED (3-foot earth cover)	0.005	200
FOXHOLES	0.1	10

*These transmission factors do not apply to ground survey dose rates.

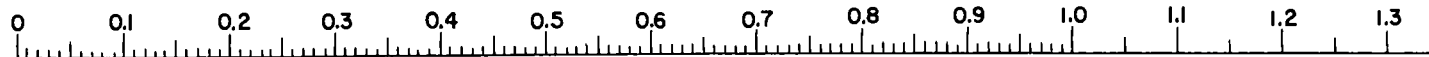
Figure 18. (Superseded) Transmission/correlation factors for residual radiation.

87. Calculations

a. *Nonstandard Decay Dose-Rate Calculations.* Dose-rate calculations in * * * other than standard.

(1) Example problem 1.

SOLUTION. Using figure 16, * * * right reference lines. Mark a point on the index scale where the hair-line intersects it. Then pivot the

CORRECTION FACTOR (HIGH n)

TIME
↓
HOURS
AFTER
BURST

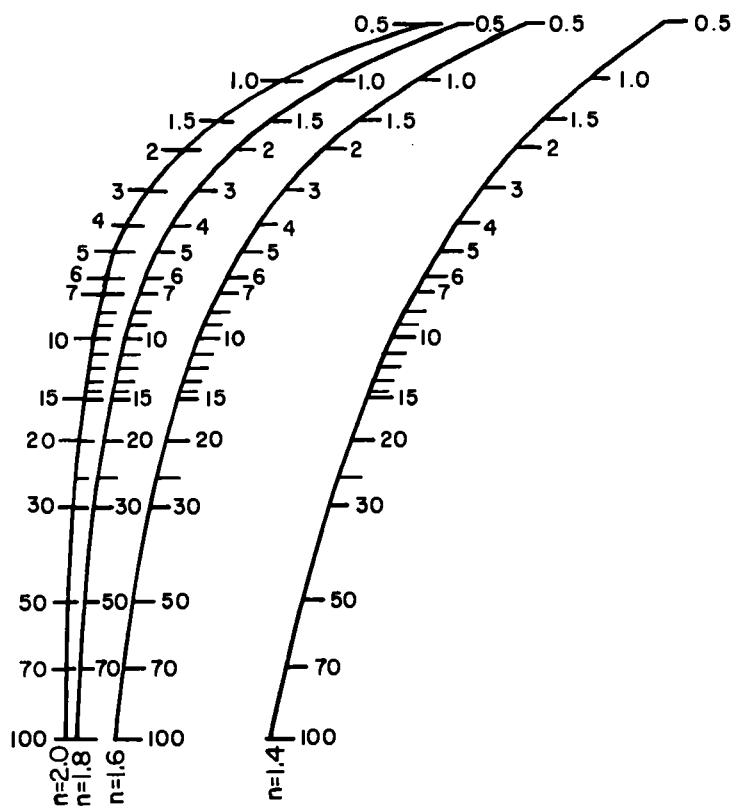


Figure 23. (Superseded) Correction factor for nonstandard decay (High n).

hairline about this point to the 100 rad/hr tickmark on the R_1 scale. Read the dose * * * the R_1 scale.

* * * *

c. *Example Problems.* The following example * * * in b above.

(1) *Example problem 1.*

* * * *

ANSWER. 656 rad.

SOLUTION. The dose rate * * * from figure 16. On figure 17, using an R_1 value of 350 rad/hr with the given values of T_e ($H + 2$) and T_s (8 hours), read a calculated dose of 410 rad. Find the correction * * * the correction factor.

Thus:

$$\begin{aligned} D_t &= D_s \times CF \\ &= 410 \text{ rad} \times 1.6 \\ &= 656 \text{ rad.} \end{aligned}$$

* * * *

97. Signs

(Superseded)

The radiological contamination marking sign will be in the shape of a right-angled isosceles triangle with a base of approximately 11½ inches and sides of approximately 8 inches. The triangle is painted yellow on both sides. On the side facing away from the contamination appear the trefoil and the words DANGER ATOM in magenta color. The other side of the marker contains details of contamination as indicated in figure 27. Under combat or disaster conditions when standard colors are not available, the trefoil and other markings may be painted or marked with black on white background. The word DANGER and the trefoil may be omitted under combat conditions or when the warning is posted in the territory of another nation. This marker is based upon MIL STD 450A and STANAG 2002.

103. Operation Exposure Guidance

a. *Categories of Exposure.* To effectively utilize * * * to radiation exposure. The values in tables IV and V are based on the assumption that human injury due to radiation exposure

consists of a reparable fraction which the body is capable of repairing at the rate of 2.5 percent per day, for dose ranges indicated or lower.

* * * *

b. *Degrees of Risk.* Even though it * * * (1- to 7-day) operation. A negligible risk practically assures the commander of the complete safety of his troops. A moderate risk * * * in a above.

* * * *

104. Radiation Exposure Records

The operation exposure * * * a later time.

* * * *

b. *Radiation Dose Status Chart.* Since the OEG * * * the platoon column. The dose received, in units of 10 rad, is posted daily or after each exposure and is indicated by an upright tally mark: || for 20 rad, |||| for 40 rad, ||||| for 60 rad, and so on, in the appropriate date column. By using the * * * like table VI. The 2d platoon of company A received 20 rad on 1 June, 20 rad on 2 June, and 30 rad on 7 June, a total of 70 rad in one week. Note that even * * * current radiation records.

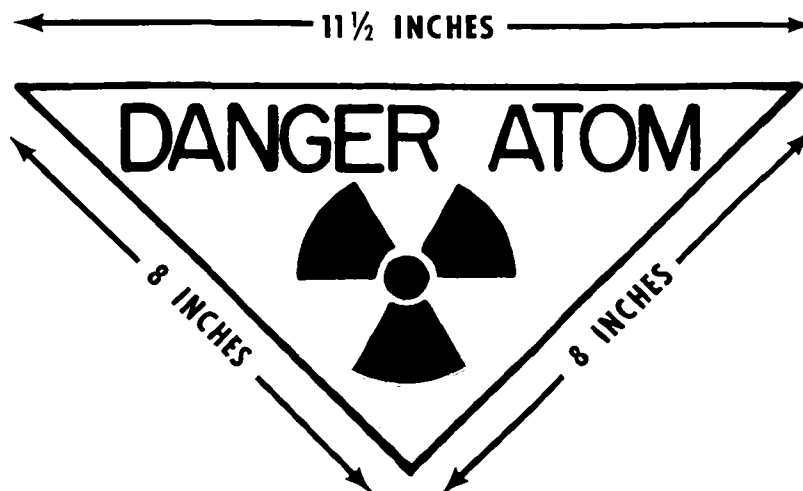
105. Effective Dose

As time passes * * * the unrecovered dose. For example, a dose of 75 rad received over a period of 30 days at 2.5 rad each day is theoretically the same as absorption of a dose of approximately 50 rad on the thirtieth day. In other words, on the thirtieth day the effective dose is approximately 50 rad although a total dose of 75 rad has been absorbed. Similarly, if a * * * dose per day.

106. Category Determination

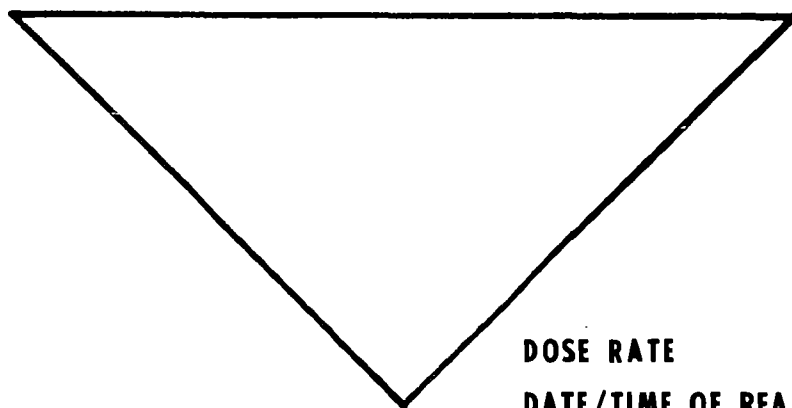
a. *Example.* (Superseded) For an understanding of category determination, consider the status of the 2d platoon of company A as depicted in table VI. As seen in the table the 2d platoon became LRRS on 7 June, having received a dose of 70 rad in one week. If the platoon does not receive any radiation during the remainder of the month, at the end of the 30 days it can be reclassified as FRRS since it will have received a dose of less than 75 rad in one month.

* * * *



FRONT

SURFACE OF MARKER FACING AWAY FROM CONTAMINATION



REAR

**DOSE RATE
DATE/TIME OF READING
DATE/TIME OF BURST (IF KNOWN)**

SURFACE OF MARKER FACING CONTAMINATION

Figure 27. (Superseded) Radiological contamination marking sign.

108. Surgeon

After the staff * * * that particular unit.

d. (Superseded) The surgeon's understanding of the effect of radiation on health is of particular importance in evaluating the effect of further radiation on troops who have already been exposed to radiation. The surgeon considers the effects of radiation on troops as one of the many factors that affect the health of the command (other factors being the effects of chemical and biological agents, natural disease, injury, and so forth).

118. Processing of Information

During the evaluation * * * is presented below.

c. *Presentation and Dissemination* (Superseded). Data from the radiological situation map is converted to the form necessary for intelligence reports and disseminated. Normally reports of areas of contamination are disseminated as NBC 5 (nuclear) reports as prescribed in STANAG 2103 (app. III). For discussion of overlays, see paragraphs 141 through 143.

127. Determination of Decay Rate (H-Hour Known)

e. *Mathematical Method for Determination of n*. The formula for * * * (a above) for n.

Location C. (Superseded)

$$n = \frac{\ln \left(\frac{79}{50} \right)}{\ln \left(\frac{2.5}{1.5} \right)} = .894$$

$$\text{Average } n = \frac{.930 + .955 + .894}{3} = \frac{2.779}{3} = .926 = .93.$$

128. Calculation of H-Hour (Superseded)

a. *Mathematical Calculation of H-Hour*. H-hour may be calculated using the following procedure:

$$T_1 = \frac{T_b - T_a}{\left(\frac{R_a}{R_b} \right)^{\frac{1}{n}} - 1}$$

where:

T_1 = time after shot at which reading R_a was made.

$T_b - T_a$ = interval between readings R_a and R_b .

The value of $\left(\frac{R_a}{R_b} \right)^{\frac{1}{n}}$ can be calculated or may be read from a family of curves (fig. 30). This calculational procedure can be made using an assumed decay exponent or one that has been determined experimentally. For example:

- (1) Suppose monitoring reports R_a and R_b represent the earliest and latest data available for a particular location within the contaminated area.

$R_a = 112$ rad (0500 hours, 15 January)

$R_b = 24$ rad (2200 hours, 15 January)

Then:

$$T_1 = \frac{17 \text{ hours}}{(4.67)^{\frac{1}{n}} - 1}$$

- (2) From figure 30, assuming $n = 1.2$:

$$T_1 = \frac{17 \text{ hours}}{3.6 - 1} = 6.54 = 6.5 \text{ hours.}$$

- (3) Since T_1 is the time after H-hour at which reading R_a was made, then
H-hour = $T_a - T_1 = 0500$ hours, 15 January — 6.5 hours
= 2230 hours, 14 January.

b. *Use of ABC-M1 Radiac Calculator to Determine H-Hour*. The ABC-M1 radiac calculator may be used in lieu of the above mathematical procedure to determine H-hour as follows:

- (1) Choose two readings, for example, the first and last readings made at location A.

Time	Dose Rate
1600 hours	50 rad/hr
1830 hours	40 rad/hr

Locate the two dose rates on the outer disc. Determine the time interval between the two readings—

Time interval = 2½ hours.

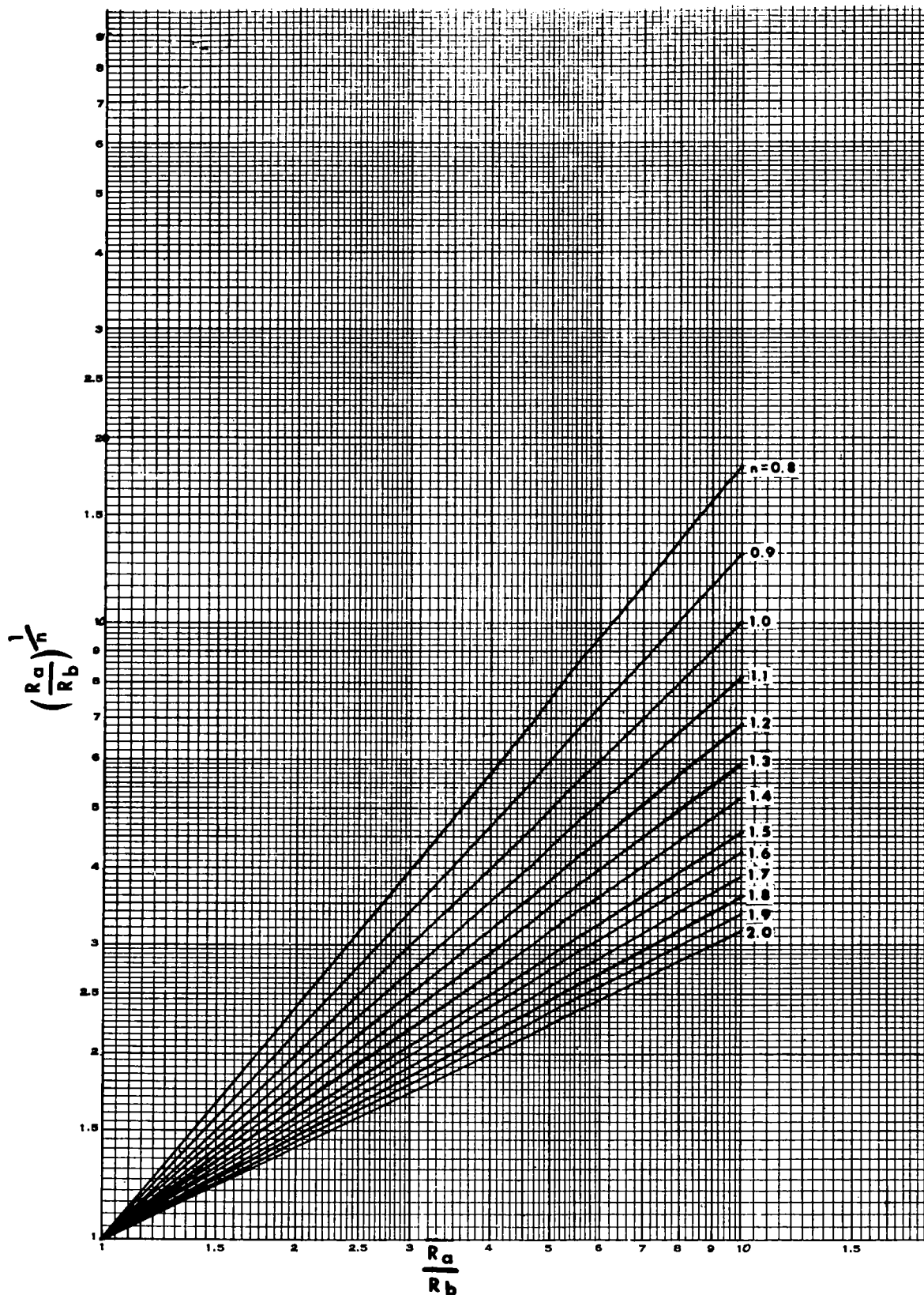
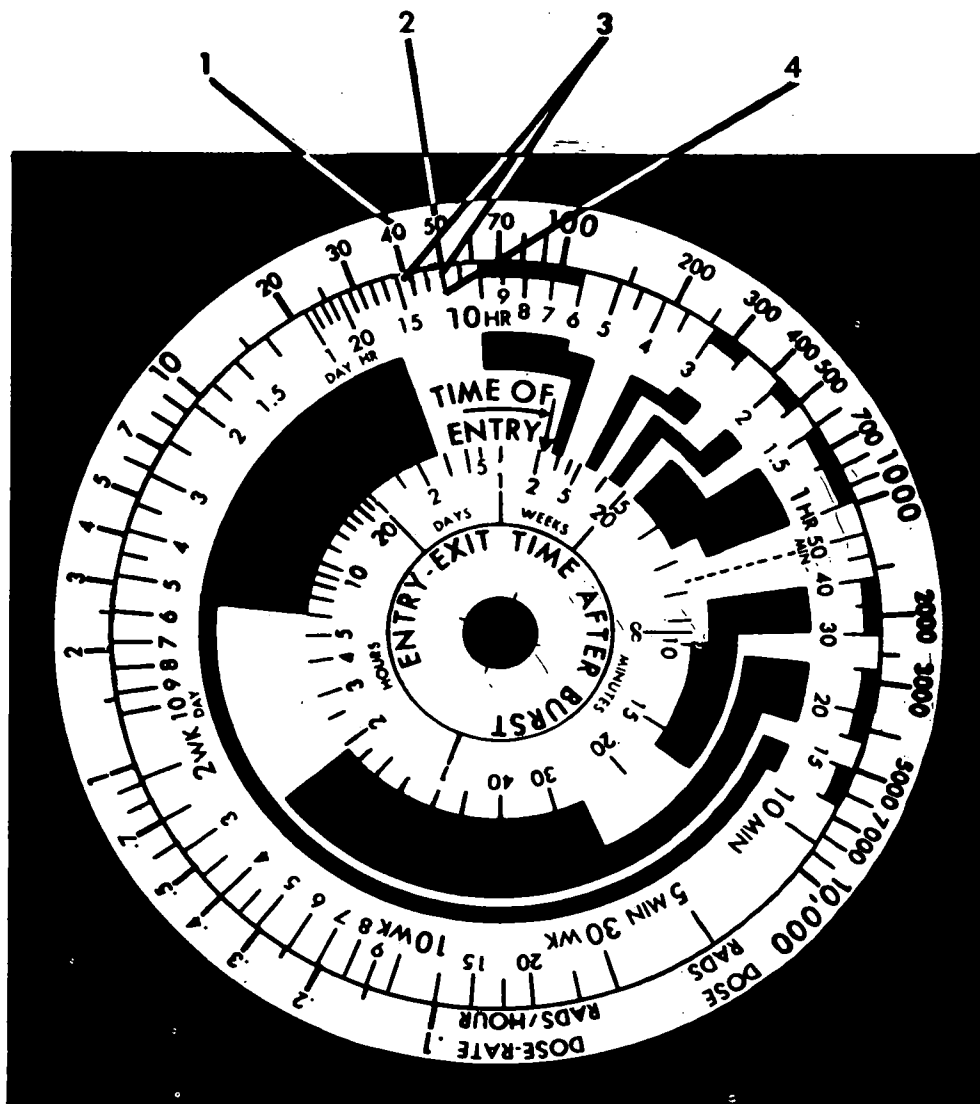


Figure 30. (Superseded) Value of $\left(\frac{R_a}{R_b}\right)^{\frac{1}{n}}$



1. 40 rad/hr on outer disc.
2. 50 rad/hr on outer disc.
3. 2½-hr interval on intermediate disc.
4. Reading of 12 hrs.

Figure 30.1 (Added) Determination of H-hour using the ABC-MI calculator.

- (2) Move the intermediate disc until a time interval of $2\frac{1}{2}$ hours coincides with the 40 and 50 rad/hr readings on the outer disc (fig. 30.1). Read the time under the 50 rad/hr as 12 hours. The 50 rad/hr dose rate was read at 1600; thus, 1600 hours corresponds to

$H + 12$. This means that H-hour was 12 hours earlier than 1600.

$$H\text{-hour} = 1600 - 1200 = 0400 \text{ hours.}$$

Note. This calculation is made assuming standard decay ($n = 1.2$).

129. Determination of Decay Rate (H-Hour Unknown)

Rescinded

APPENDIX I

REFERENCES

Appendix I is changed as follows:

Change the title of FM 21-40 to Small Unit Procedures in Chemical, Biological, and Radiological (CBR) Operations.

Change the title of DA Pam 310-3 to Index of Doctrinal, Training and Organizational Publications.

Change "(S) FM 101-31" to (S) FM 101-31-2 (no title change).

Add—

FM 101-31-1 Staff Officers' Field Manual: Nuclear

Weapons Employment;

FM 101-31-3 Staff Officers' Field Manual: Nuclear Weapons Employment;

STANAG 2002 Marking of Contaminated Areas.

Delete:

DA Pam 310-7

TB CML 85

APPENDIX II
SAMPLE APPENDIX TO CBR ANNEX OF AN INFANTRY DIVISION SOP

6. Reports

* * * * *

e. Communications.

(1) *Precedence.* Contact reports will be *

reported with **IMMEDIATE** precedence by units in areas not predicted to receive fallout. All other reports * * * and operational requirements.

* * * *

APPENDIX III
REPORTING NUCLEAR DETONATIONS AND RADIOACTIVE FALLOUT (STANAG 2103)
(SUPERSEDED)

1. Standardized Report Formats

The standardized formats for reporting enemy nuclear attacks are—

- a. *NBC 1.* Observers' initial report, giving basic data.
- b. *NBC 2.* Report used for passing evaluated data.
- c. *NBC 3.* Immediate warning of expected contamination.
- d. *NBC 4.* Report of radiation dose-rate measurements.
- e. *NBC 5.* Report of areas of contamination.

2. Letter Items

The letter items used in all reports have the following meanings:

- A. Strike serial number(s).
- B. Position of observer (UTM or place).
- C. Grid or magnetic (say which) bearing or azimuth of attack from observer (in degrees or mils, say which).
- D. Date/time attack started (ZULU time).
- E. Illumination time (seconds).
- F. Location of attack (UTM or place) (actual or estimated, say which).
- G. Means of delivery if known.
- H. Type of burst—air, surface, or unknown (say which)—including height if known.
- I. (Not used for nuclear report.)
- J. Flash-to-bang time (seconds).
- K. Crater present or absent and diameter if known (meters).
- L. Fireball width, immediately after passage of shock wave (sound of detonation) (degrees or mils, say which).
- M. Cloud height top or bottom (10 minutes after burst; in degrees, mils, meters, or feet—say which).
- N. Estimated yield (KT).
- O. Reference date/time for estimated contours when not H + 1 hour.
- P. For radar purposes only—
 - P.A. UTM coordinates of points to outline external contours of radioactive cloud.
 - P. B. Effective wind direction, from, in degrees magnetic or mils (say which).
- Q. Location of reading.
- R. Dose rate (rad/hr*). The words "initial," "increasing," "peak," or "decreasing" may be added. When decay rate is reported, the words "decay normal," "decay fast," or "decay slow," or the actual value of decay constant may be inserted.
- S. Date/time of reading (ZULU).
- T. H + 1 date/time.
- U. 1,000 rad/hr contour line coordinates (UTM) (red).
- V. 300 rad/hr contour line coordinates (UTM) (green).
- W. 100 rad/hr contour line coordinates (UTM) (blue).
- X. 30 rad/hr contour line coordinates (UTM) (black).
- Y. Bearing or azimuth of left, then right, radial lines (degrees or mils, say which—4 digits each).
- Z. Effective wind speed (KPH), 3 digits; downwind distance of Zone 1 (km), 3 digits; and cloud radius (km), 2 digits.

3. Format: NBC 1

a. The items "type of report," D, H, and either items B and C or item F must always be reported; other items are optional.

b. Users of NBC 1 are not confined solely

* Changed from "r/hr" throughout reports.

to the use of letter items shown in the examples; other letter items may be added at the users' discretion.

Letter	Meaning	Example
	Precedence*	_____
	Date/Time (ZULU)	_____
	Security	_____
	From	_____
	To	_____
	Type of Report	NBC 1 (Nuclear).
A.	Strike serial number	
B.	Position of observer (UTM or place).	B. LB 196400
C.	Grid or magnetic (say which) bearing or azimuth of attack from observer (in degrees or mils, say which).	C. Grid 60 degrees.
D.	Date/time attack started (ZULU).	D. 201405 Z
E.	Illumination time (seconds) or time attack ended.	
F.	Location of attack (UTM or place) (actual or estimated, say which).	E. 4
G.	Means of delivery if known.	
H.	Type of burst—air, surface, or unknown (say which)—including height if known.	
J.	Flash-to-bang time (seconds).	
K.	Crater present or absent and diameter if known (meters).	
L.	Fireball width, immediately after passage of shock wave (sound of detonation) (degrees or mils, say which).	
M.	Cloud height top or bottom (10 minutes after burst; degrees, mils, meters, or feet—say which).	M. 40,000 feet TOP

* As appropriate or as per unit SOP.

4. Format: NBC 2

a. This report is normally based on two or more NBC forms 1. It includes an estimated GZ and, in the case of nuclear detonations, an evaluated yield.

b. When adjacent agencies, e.g., Navy and National NBC defense organizations, use a different fallout prediction system, this form may be sent to provide basic data for their fallout computations.

c. Items A, D, F, H, and N may be repeated as often as necessary to produce a summary report.

d. Users of NBC 2 are not confined solely to the use of the letter items shown in the example; other letter items may be added at the users' discretion.

Letter	Meaning	Example
	Precedence	_____
	Date/Time (ZULU)	_____
	Security	_____
	From	_____
	To	_____
	Type of Report	NBC 2 (Nuclear)
A.	Strike serial number.	A. 24
D.	Date/time attack started (ZULU).	D. 201405 Z
F.	Location of attack (UTM or place) (actual or estimated, say which).	F. LB 187486
G.	Means of delivery if known.	
H.	Type of burst—air, surface, or unknown (say which).	H. Surface
N.	Estimated yield (KT)	N. 50

5. Format: NBC 3

a. When adjacent agencies, e.g., Navy and National NBC defense organizations, use a different fallout prediction system, NBC 2 may be sent to provide basic data for their fallout computations.

b. Users of NBC 3 are not confined solely to the use of the letter items shown in the example; other letter items may be added at the users' discretion.

Letter	Meaning	Example
	Precedence	
	Date/Time (ZULU)	(a telephone or radio message).
	Security	
	From	
	To	
	Type of Report	NBC 3 (Nuclear)
D.	Date/time attack started (ZULU).	D. 201405 Z
F.	Location of attack (UTM or place) (actual or estimated, say which).	F. LB 187486
Y.	Bearing or azimuth of left, then right, radial lines (degrees or mils, say which; 4 digits each).	Y. 0272-0312 degrees.
Z.	Effective wind speed (KPH), 3 digits; downwind distance of Zone 1 (km), 3 digits; cloud radius (km), 2 digits.	Z. 019-025-05

6. Format: NBC 4

a. Letter items Q, R, and S may be repeated as often as necessary.

b. Radiation dose rates are measured in the open, one meter above ground; other conditions will be specified in the message.

c. Users of NBC 4 are not confined solely to the use of the letter items shown in the examples; other letter items may be added at the users' discretion.

Letter	Meaning	Example
	Precedence	
	Date/Time (ZULU)	
	Security	
	From	
	To	
	Type of Report	NBC 4
Q.	Location of reading	Q. LB 123987
R.	Dose rate (rad/hr). The words "initial," "increasing," "peak," or "decreasing" may be added. When decay rate is reported, the words "decay normal," "decay fast," or "decay slow," or the actual value of decay constant may be inserted.	R. 35
S.	Date/time of reading (ZULU) (This is NOT normalized to H + 1 hour.)	S. 201735 Z
		Q. LB 129965
		R. 60
		S. 201650 Z
		Q. LB 146808
		R. 27 Increasing
		S. 201710 Z

7. Format: NBC 5

a. The form is best sent by means of a trace or overlay if time and distance permit.

b. When the contamination arises from a single enemy or unidentified burst, the dose rate will always refer to H + 1 hour, and the letter item T will be used. But when there have been several detonations at different times or on different days and no single H + 1 hour is possible, then the dose rates will be reported as at a specified time using letter item O. Letter items O and T are therefore alternative and cannot both be used in the same report.

c. It is not necessary or even desirable to re-

port all four of the contours of different dose rates. Four are given to provide flexibility. (In the example, only two are reported.)

d. Letter item X is used for 30 rad/hr contour line.

e. When a contour closes to form a complete ring, the first coordinate is repeated at the end (see example for 300 rad/hr).

f. Colours when used in plotting, and when sending the report by means of a trace, are as follows:

- (1) Red for 1,000 rad/hr.
- (2) Green for 300 rad/hr.
- (3) Blue for 100 rad/hr.
- (4) Black for 30 rad/hr.

g. Contour lines will be annotated with the dose rates.

h. Decay rates will be transmitted when requested.

i. Users of NBC 5 are not confined solely to the use of the letter items shown in the example; other letter items may be added at the users' discretion.

Letter	Meaning	Example
	Precedence	
	Date/Time (ZULU)	
	Security	
	From	
	To	
	Type of Report	NBC 5 (Nuclear)
A.	Strike serial number(s) causing contamination (if known).	A. 24
O.	Reference date/time for estimated contours (see b above) when not H + 1 hour.	
T.	H + 1 date/time	T. 201505 Z
U.	1,000 rad/hr contour line coordinates.	
V.	300 rad/hr contour line coordinates.	V. ND 651455 ND 810510 ND 821459 ND 651455
W.	100 rad/hr contour line coordinates.	W. ND 604718 ND 991686 ND 114420 ND 595007
X.	30 rad/hr contour line coordinates.	

8. Format for Effective Wind Message

a. The format for the effective wind message, transmitted with six wind speeds and directions, is as follows:

Effective Wind Message

ZULU	D D t t t t
ALFA	d d d s s s
BRAVO	d d d s s s
CHARLIE	d d d s s s
DELTA	d d d s s s
ECHO	d d d s s s
FOXTROT	d d d s s s

b. ZULU D D t t t t is the date and time at which the real winds were measured (for example, 250600 is the 25th day of the month at 0600 hours).

c. ALFA, BRAVO, CHARLIE, DELTA, ECHO, and FOXTROT are the yield groups:

- (1) ALFA is 2 KT or less.
- (2) BRAVO is more than 2 KT to 5 KT.
- (3) CHARLIE is more than 5 KT to 30 KT.
- (4) DELTA is more than 30 KT to 100 KT.
- (5) ECHO is more than 100 KT to 300 KT.
- (6) FOXTROT is 300 KT to 1 MT.

d. Effective wind direction is d d d and wind speed in kilometers per hour is s s s (for example, ALFA 080025 is an effective wind direction of 80 degrees and an effective wind speed of 25 kilometers per hour for yields of 2 KT or less).

Note. TM 3-210 contains information of the use of the effective wind message.

APPENDIX IV

OPTIMUM TIME FOR EXIT OF FALLOUT AREAS

(ADDED)

1. General

Radiological fallout may present a serious radiological hazard to units that remain in the contaminated area. The efficient use of shelters such as field emplacements will provide the best protective measures against nuclear radiation for troops in the field. If the shelter provides any appreciable amount of protection, it will generally be advantageous to remain in the shelter and improve it rather than to attempt to evacuate to an uncontaminated area. However, if the situation permits, and with approval of higher headquarters, the commander may decide to move out of the radiologically contaminated area. By evacuating the contaminated area at the optimum exit time, the radiation dose to personnel will be kept as low as is possible under the circumstances.

2. Input Data Required

To compute the optimum exit time from a fallout area, the following information must be known:

a. Time of Detonation. The time of detonation of the nuclear weapon that produced the fallout on the unit's position must be known. If the nuclear burst was not sighted by the unit, the H-hour will be provided by the nearest CBRE.

b. Location of Uncontaminated Area. When moving from a fallout contaminated area, the unit should move to an uncontaminated location. This will necessitate waiting until fallout is complete on the present and the future position.

c. Average Transmission Factor. The average transmission factor of the fallout shelters and the vehicles used to leave the contaminated area should be computed. Since data are not available, use figure 18. Since all shelters will

not be the same, an average value should be used. The transmission factor of a vehicle may be estimated using the values in figure 18. A unit moving on foot will be fully exposed and have a transmission factor of 1.0.

d. Time to Evacuate the Area. The time to load on vehicles and move out of the contaminated area must be estimated. In order to minimize exposure time, it may be necessary to temporarily abandon nonessential items and recover them at a later time when the dose rate has decayed to a low value.

3. Abbreviations

The following abbreviations are used in the exit time computations:

A_s = Average transmission factor for the fallout shelters.

A_e = Average transmission factor after leaving shelters during movement out of the area.

T_{ev} = Time (in hours) required to move out of the contaminated area.

4. Computations

The optimum exit time is computed by the three following steps:

a. Calculate the Transmission Factor Ratio $\frac{A_s}{A_e}$. Divide the average transmission factor for the fallout shelters (A_s) by the average transmission factor during evacuation of the area (A_e).

b. Determine the Multiplication Factor. Enter the vertical axis of figure 37 at the value determined in *a* above. Move horizontally along the $\frac{A_s}{A_e}$ value to the curve. Move straight down to horizontal axis and read the multiplication factor.

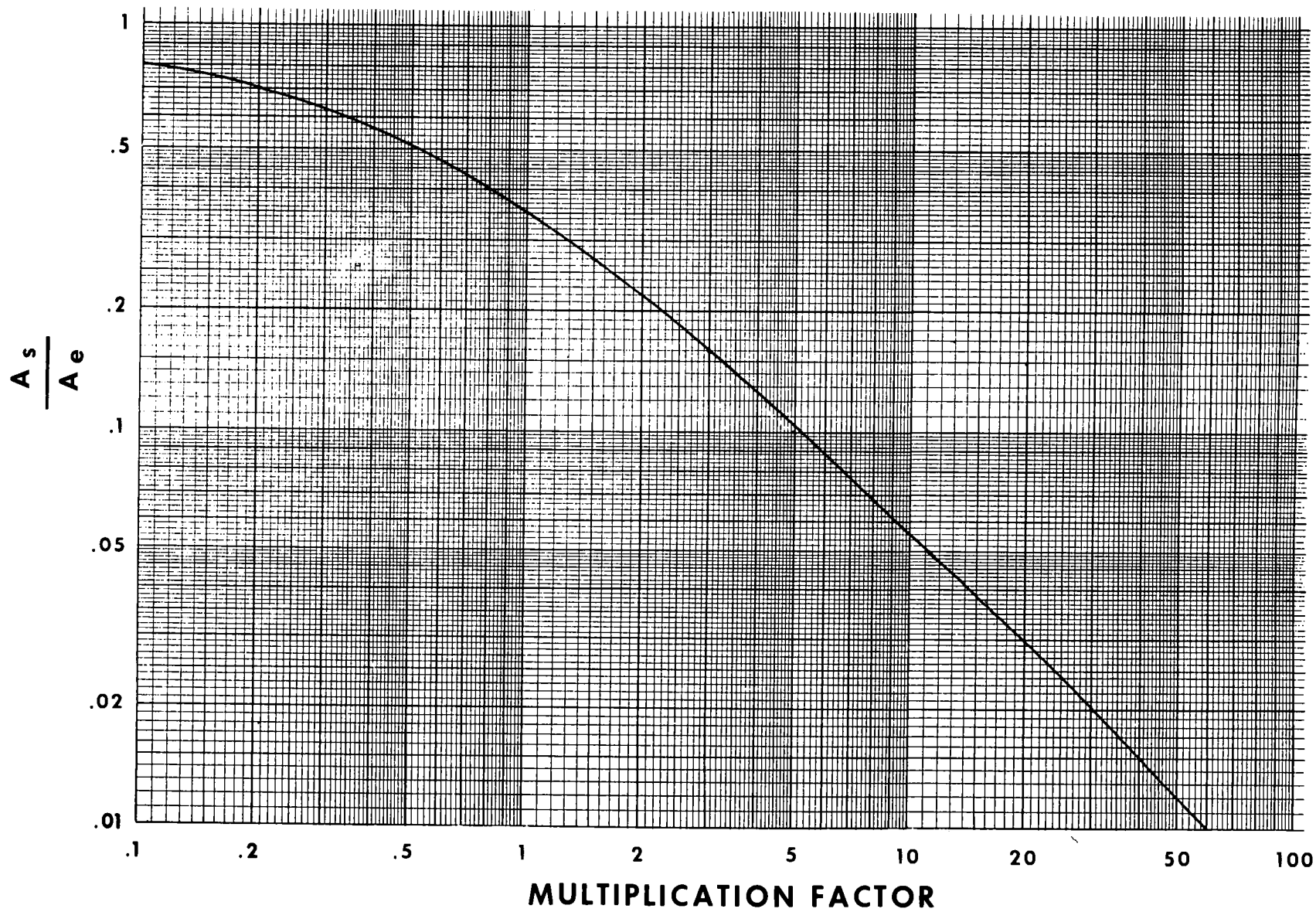


Figure 37. (Added) Multiplication factor graph.

c. *Calculate the Optimum Exit Time.* Multiply the multiplication factor by the evacuation time (T_{ev}). The product is the optimum time, in hours after detonation, that the unit should leave its shelters and evacuate the area. Mathematically, this can be expressed as:

$$\text{Optimum exit time} = \text{Multiplication factor} \times T_{ev}.$$

5. Special Considerations

a. For ratios of $\frac{A_s}{A_e}$ that are close to or greater than 0.5, the unit should evacuate the fallout area as soon as possible.

b. Leaving the contaminated area at the optimum time will result in the smallest dose possible received by the unit. If the unit commander is willing to accept up to a ten percent increase in dose above the minimum possible dose, he may leave the shelters any time between one-half and twice the optimum time.

c. If possible, personnel should improve their shelters while waiting for the optimum exit

time. The estimate of the optimum exit time should be recalculated if significant improvement is made in the shelters. Improved shelters will mean that the unit should remain in the shelters for a longer period of time to minimize the dose to the personnel.

6. Sample Problem

GIVEN.

$$A_s = 0.1 \text{ (foxhole).}$$

$$A_e = 0.6 \text{ (personnel carrier).}$$

$$T_{ev} = 1 \text{ hour.}$$

FIND. Optimum exit time.

$$\text{SOLUTION. } \frac{A_s}{A_e} = \frac{0.1}{0.6} = 0.167.$$

$$\text{Multiplication factor} = 2.80.$$

$$\begin{aligned} \text{Optimum exit time} &= \text{multiplication factor} \\ &\times T_{ev} = 2.80 \times 1 = 2.80, \text{ or about} \\ &H + 3 \text{ hours.} \end{aligned}$$

Note. The unit may depart between $H + 1.5$ and $H + 6$ hours without a significant increase in dose to the personnel.

By Order of the Secretary of the Army:

3000015518

EARLE G. WHEELER,
General, United States Army,
Chief of Staff.

Official:

J. C. LAMBERT,
Major General, United States Army,
The Adjutant General.

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CINFO (2)
TIG (2)
TJAG (2)
TPMG (1)
TAG (5)
CofCh (1)
OPO (2)
TSG (1)
CofEngrs (1)
C/COMMEL (1)
CofT (1)
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USAMC (2)
USACDC (5)
USACAG (1)
USACSSG (1)

USACDEC (1)
USASDEG (1)
USAWECOM (3)
USA CD Agcy (1) except
 USACBRCDA (25)
 USAICDA (5)
 USAECDA (10)
ARADCOM (2)
ARADCOM Rgn (2)
OS Maj Comd (5) except
 USAREUR (50)
LOGCOMD (2)
MDW (2)
Armies (20)
Corps (5)
Div (5)
Bde (5)
Regt/Gp/Bg (2)
Bn (1)
CoBtry (1)
CC (2)
Br Svc Sch (5) except
 MFSS (15)
 USAARMS (10)
 USAES (20)
 USASCS (25)

NG: State AG (3); Units—same as Active Army except allowance is one copy to each unit.
USAR: Units—same as Active Army except allowance is one copy to each unit.
For explanation of abbreviations used, see AR 320-50.

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